INTERREGIONAL COMPETITION IN THE U. S. SWINE-PORK INDUSTRY: AN ANALYSIS OF OKLAHOMA'S EXPANSION POTENTIAL

By

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PREFACE

This study concerns an analysis of the potential for expanding Oklahoma's swine-pork industry. The primary objective of the study is to identify the economic conditions necessary for Oklahoma to compete favorably with other regions in producing and/or slaughtering hogs and to determine the limits to expansion possibilities in both of these sectors. An integrated programming model consisting of reactive programming and a linear programming formulation of a transhipment model is utilized to address the primary objective. The integrated programming model is solved to obtain least cost production, live hog shipment, slaughter and pork shipment patterns which fulfill spatial equilibrium demands under several sets of exogenous conditions. Conclusions concerning Oklahoma's production and slaughter expansion potentials, limits to these potentials and the sensitivity of the Oklahoma swine-pork industry to exogenous changes are drawn from these solutions.

There are many people who can rightfully claim at least partial credit for this study. Foremost among these is my adviser, Dr. Joseph E. Williams, whose guidance, assistance and understanding throughout my college career elicit my deepest respect and heartfelt thanks. To Dr. J. Bruce Bullock, Dr. John E. Ikerd, and Dr. James N. Trapp go my thanks for their serving as members of my committee and providing invaluable assistance throughout the course of this study.

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CHAPTER I

INTRODUCTION

Economic Importance of Swine Production and Slaughter in Oklahoma

Considerable interest has been expressed by swine producers, pork packers and processors, and university personnel concerning the possibility of future expansion of Oklahoma's swine-pork industry. Even though this interest has existed for several years, Oklahoma hog numbers have not increased. In fact, they have decreased. A review of the historical role of swine production and processing in Oklahoma provides a benchmark for the study of expansion potential.

Swine production has historically comprised a minor portion of the state's agricultural industry. This minor role is exemplified by the fact that Oklahoma's highest recorded beginning-year hog inventory occurred in 1911 when 1.6 million head were reported on Oklahoma farms. Hog inventories on December 1, 1978, were 315,000 head (Oklahoma Department of Agriculture, 1979).

Table I shows the percentage of Oklahoma's total cash farm receipts and total livestock and livestock products cash receipts for which hogs accounted in selected years from 1959 to 1979. In addition, the rank of cash receipts for hogs among cash receipts for all Oklahoma enterprises is shown for the same years. Note the decreasing percentages of receipts in both categories and the lower ranking over time.

TABLE I

PERCENT OF OKLAHOMA'S a) TOTAL CASH RECEIPTS AND b) TOTAL LIVESTOCK AND LIVESTOCK PRODUCTS CASH RECEIPTS FOR WHICH HOGS ACCOUNTED AND RANK OF SWINE RECEIPTS AMONG RECEIPTS FOR ALL OTHER ENTERPRISES, 1959-1979

Year	Proportion of Total Cash Receipts	Proportion of Livestock and Livestock Products Receipts	Rank Among Enterprises
	(percent)	(percent)	(no.)
1959	3.60	6.37	5
1964	2.94	4.91	8
1969	3.18	4.40	7
1974	2.21	3.85	8
1979	1.50	2.31	9

Source: Oklahoma Department of Agriculture, 1960, 1965, 1970, 1975, and 1979.

Oklahoma's farm economy is based primarily on cattle and winter wheat. Table II shows cash receipts for these commodities and for hogs and pigs for selected years from 1959 through 1979. While cash receipts for hogs have grown by 105 percent over this 20 year period, cash receipts for cattle and wheat have grown by 471 and 438 percent, respectively. These data suggest a decrease in the position of hog production in Oklahoma relative to the state's two major enterprises.

Oklahoma's hog industry produces only a small portion of the national total. Oklahoma's live hog production, percentage of national production, and state rank for 1959-1979 are shown in Table III. These data show an obvious downward trend in all three categories.

An integral participant in the hog industry in Oklahoma is, obviously, the packer-processor. Table IV shows hog slaughter in Oklahoma, percentage of national slaughter, and state rank for 1959-1979.

TABLE II

OKLAHOMA FARM INCOME FROM CATTLE, WHEAT, AND HOGS, 1959-1979

Year	Cattle	Wheat	Hogs & Pigs
		(thousand dollars)	
1959	256,127	157,126	22,896
1964	274,935	132,181	18,346
1969	445,772	144,296	29,863
1974	761,000	531,000	43,000
1979	1,462,000	845,000	47,000

Source: Oklahoma Department of Agriculture, 1960, 1965, 1970, 1975, and 1979.

TABLE III

OKLAHOMA HOG PRODUCTION, PERCENT OF NATIONAL PRODUCTION AND STATE RANK, 1959-1979

Year	Oklahoma Production	Proportion of National Total	State Rank
	(percent)	(percent)	(no.)
1959	192,061	.896	22
1964	145,318	.690	24
1969	138,255	.679	22
1974	125,236	.625	24
1979	113,825	.503	26

Source: U. S. Department of Agriculture, 1960A, 1965A, 1970A, 1975A, and 1981D.

The large relative increase in Oklahoma hog slaughter from 1974 to 1979 corresponds with the closing of beef slaughter operations by Wilson Foods Corporation at its Oklahoma City plant and the subsequent adaptation of this plant to slaughter hogs only.

TABLE IV

OKLAHOMA HOG SLAUGHTER, PERCENT OF NATIONAL SLAUGHTER AND STATE RANK, 1959-1979

Year	Liveweight Slaughter	Proportion of National Total	State Rank
	(1000 pounds)	(percent)	(no.)
1959	173,542	.899	25
1964	172,740	.863	24
1969	179,151	.895	24
1974	185,693	.930	21
1979	269,614	1,251	21

Source: U. S. Department of Agriculture, 1960B, 1965B, 1970B, 1975B, and 1980E.

A comparison of Tables III and IV indicates that Oklahoma's hog slaughter has exceeded its production for approximately 20 years and that slaughter was over twice as large as production in 1979. These comparisons are valid at present but it should be noted that in February, 1981, Wilson Foods Corporation announced the cessation of hog slaughtering at its Oklahoma City plant, effective July 1, 1981. The closing of Wilson Foods Corporation's Oklahoma City hog slaughter facilities and its impact on potential development of Oklahoma's swine industry is one of the primary considerations of this thesis.

The Problematic Situation

The previously mentioned interest in expansion of Oklahoma's hog industry is the result of several items of information. Most of this information is microeconomic in nature. That is, it deals with the individual producer and makes hog production appear economically feasible from the producer's viewpoint. In addition, information regarding locational advantages and projected population movements in the United States gives credence to optimism concerning Oklahoma's expansion possibilities from a macroeconomic (factors affecting the entire industry) point of view.

Production cost data from the U. S. Department of Agriculture show that the Southwest (Oklahoma and Texas) is in a relatively good competitive position with respect to the Corn Belt and Southeast regions (U. S. Department of Agriculture, 1978A, 1979, 1980A, and 1981B). Table V shows these estimates. The Southwest holds an advantage over Southeast states and only a slight disadvantage to Corn Belt states in farrow-to-finish swine enterprise costs. When the growth of hog production in the Southeast over the last 20 years is considered, the cause for optimism is obvious. The USDA budgets from which these production cost data are obtained appear in Appendix A.

Additional encouragement concerning future expansion of Oklahoma's swine-pork industry is garnered from the fact that many profit-maximizing linear program solutions for Oklahoma farms have contained swine enterprises of some sort. Many of these enterprises have been in the solutions at their maximum constrained levels. While these favorable solutions have not occurred in the past two years due to depressed hog prices, their frequency and consistency under more normal market conditions are encouraging.[1]

TABLE V

SWINE PRODUCTION COSTS PER 100 LBS. BY REGION, 1976-1979

Year	Region		
	North Central	Southeast	Southwest
		($)	
1976	48.55	50.22	47.95
1977	47.28	49.58	47.14
1978	48.49	51.36	49.50
1979	53.96	58.14	55.58

Source: U. S. Department of Agriculture, 1978A, 1979, 1980A, and 1981B.

Production inputs for hog enterprises are available in Oklahoma or nearby states. Feed grain, in the form of milo, is produced in large amounts in Kansas, Texas and Oklahoma (U. S. Department of Agriculture, 1980B). High quality breeding stock is produced by many reputable and well-known breeders. Sufficient amounts of water for swine production are available in most areas.

[1]Interview with Dr. Raleigh A. Jobes, Oklahoma State University Cooperative Extension Service, Stillwater, Oklahoma, October 10, 1980.

Possible advantages from a macroeconomic viewpoint fall into three basic categories--climate, location, and labor costs. Oklahoma's mild climate and proximity to growing Sun Belt markets for pork may well enhance its competitive position in the U. S. swine-pork industry. This possibility, however, hinges upon the magnitude of future energy price increases and technological advancements which may prevent the deterioration of the Corn Belt states' advantages as these prices rise. Labor costs in the slaughter sector are to Oklahoma's advantage. The American Meat Institute reported in its 1979 Annual Financial Review that the average hourly earnings of workers in the meat packing industry in the Southwest are $2.32 per hour less than in the Midwest and $1.93 per hour less than in the Great Lakes (American Meat Institute, 1980). In a labor intensive industry such as meat packing, the effect of this advantage is potentially great.

Oklahoma's swine-pork industry has declined even though it has apparent production and slaughter cost advantages over some regions. This decline has not been from surplus production and slaughter to deficit production and/or slaughter, it has been from deficit to deeper deficit. The decline can be seen by comparing pork consumption figures in Table VI to hog production and slaughter figures in Tables III and IV.

Why this decline? Is there a real possibility of expansion? If so, how much expansion is possible? The investigation of possible answers to these questions is the purpose of this study.

Objectives

The general objective of this study is to identify the conditions necessary for Oklahoma to compete favorable with other regions in producing and/or slaughtering swine and to determine the limits to any possible expansion of Oklahoma's swine industry. The general objective is addressed through a series of specific objectives. The specific objectives are:

1. To determine the optimal shipment patterns for live hogs and carcass pork under 1979 conditions assuming the Wilson Foods Corporation plant at Oklahoma City is both open and closed.
2. To determine optimal live hog production, slaughter, and shipping patterns to fulfill 1979 spatial equilibrium demands assuming that the Wilson Foods Corporation plant at Oklahoma City is both open and closed.
3. To determine the impact on the optimal production, slaughter, and shipping patterns resulting from the entry of a large, very efficient packer in the swine industry.
4. To determine the effect of changes in wage rates in the slaughter sector on optimal live production, slaughter and shipping patterns.
5. To determine the effect of increasing prices for truck fuel (and thus transport costs) on optimal production, slaughter, and shipping patterns.
6. To determine the optimal production, slaughter, and shipment patterns of live hogs and pork to satisfy spatial equilibrium demand quantities for projected 1990 population distributions.

Given these objectives, the hypothesis which this study investigates is:

There exist conditions under which Oklahoma can compete favorably with other regions in the production and/or slaughter of swine and under which the Oklahoma swine-pork industry can expand.

TABLE VI

POPULATION AND PORK CONSUMPTION IN OKLAHOMA, 1959-1979

Year	Per Capita Consumption	Oklahoma Population	Total Consumption
	(pounds)	(1000)	(1000 pounds)
1959	81.1	2,301,000	186,611.1
1964	76.2	2,446,000	186,385.2
1969	71.4	2,535,000	180,999.0
1974	69.1	2,681,000	185,257.1
1979	70.2	2,892,000	203,018.4

Sources: Consumption: U. S. Department of Agriculture, 1968 and 1981C.

Population: U. S. Bureau of the Census, 1961, 1971, 1976, and 1980.

The hypothesis is a generalized one. In its investigation, however, efforts are made to quantify the necessary conditions and expansion limits for each specific situation.

Procedures

Each specific objective is addressed through a prescribed procedure. The information obtained from the solutions of some objectives is used as benchmarks for comparison and/or as input data in seeking solutions for remaining objectives. The cumulative results of all specific objective solutions are then analyzed in the context of the general objective and the hypothesis being investigated.

The procedures for this study are as follows:

1. For specific objective 1: Use a linear programming transhipment model to solve for optimal live hog and pork shipments assuming production, slaughter, and consumption are distributed as in 1979 with Wilson Foods Corporation's Oklahoma City plant open and closed.
2. For specific objective 2: Use reactive programming and a transhipment model to solve for least-cost production, slaughter, and shipment patterms to satisfy spatial equilibrium demand quantities.
3. For specific objective 3: Create a new slaughter region with a capacity of two million head per year and processing costs 20 percent lower than Iowa. Locate this region in each of several cities in or near Iowa and, using reactive programming and a transhipment model, solve for least-cost production, slaughter, and shipment patterns for each plant location.
4. For specific objective 4: Use reactive programming and a transhipment model to determine optimal production, slaughter, and shipment patterns assuming wage rates for a) totally unionized labor, and b) totally non-unionized labor in the slaughter sector in all regions.
5. For specific objective 5: Solve for the optimal production, slaughter, and shipment patterns for selected levels of increased transport costs of live hogs and pork by using reactive programming and a transhipment model. Compute transport cost increases from assumed increases in fuel prices and data concerning the percentage of transport costs for which fuel accounts.

6. For specific objective 6: Use reactive programming and a transhipment model to solve for optimal production, slaughter, and shipment patterns to fulfill spatial equilibrium demand quantities based on projected 1990 population distributions.

Unless otherwise noted, all procedures assume the Wilson Foods Corporation Oklahoma City plant to be closed.

Scope and Limitations

This study is directed specifically at Oklahoma in as much as its goal is to determine whether expansion of the state's swine-pork industry is feasible. Conclusions from the study emphasize Oklahoma's potential for expansion under the various circumstances described above. These conclusions, in keeping with the theory of reactive and linear programming, are prescriptive in nature in that they describe what conditions <u>should</u> exist in light of the data used in the study.

There are several limitations to the study. Stout and Bentley (1962, pp. 1576) noted that such models ". . . may be always subject to the accusation that results derive from information too limited in scope. Whether results indicate industry diseconomies or analytical naiveties is not so easily determined." The model requires that all demand functions be of the same functional form for all regions. Supply functions are also assumed to be of identical form in all regions. The model yields, in reality, only partial equilibrium solutions due to the treatment of the industry as an entity separated from other enterprises, industries, and products. Any analysis of intraregional spatial aspects is precluded by the necessity of all regions being represented by a single point. The manual interfacing of reactive programming and the transhipment model does not allow the guarantee of spatial equilibrium conditions in live hog markets. Two additional items of data appear as limitations. They are:

1. The accuracy of transport cost figures. Transportation cost estimates for some hauls may be errant in that they do not account for backhauls or their possibility. In addition, topography is not considered a factor in estimating transport costs.
2. The use of aggregated costs of production and slaughter which may change as the structure of the industry changes in the face of expansion or contraction.

In spite of these limitations, the model appears to be well-suited to investigate the designated problem and the data appear to be the most accurate obtainable.

CHAPTER II

LITERATURE REVIEW

Samuelson (1952, p. 284) wrote that "Spatial problems have been so neglected in economic theory that the field is of interest for its own sake." While this study concerns a problem with spatial aspects, its devotion thereto is not for the sake of being spatial in nature. It is by necessity that a spatial model is chosen. A substantial amount of work has been completed in the area of spatial analysis of the U. S. livestock and meat sectors and in computational methods for spatial studies. This chapter is devoted to a review of selected literature concerning these topics.

Spatial Theory

The economics of spatially separated systems have been of interest for some time. Hoover (1948), Losch (1954), and others expanded the modern versions of general equilibrium theory as proposed by Hicks (1939) and Samuelson (1947) to encompass the spatial dimension. Enke (1951), Baumol (1952), and Samuelson (1952) then set out the problem of interconnected markets in a form whereby space is treated explicityly and for which linear programming may be employed as an analytical tool. In doing so, Enke (1951, p. 41) described his formulation as follows:

> There are three (or more) regions trading a homogeneous good. Each region constitutes a single and distinct market. The regions of each possible pair of regions are

> separated--but not isolated--by a transportation cost per physical unit which is independent of volume. There are no legal restrictions to limit the actions of the profit seeking traders in each region. For each region, the functions which relate local production and local use to local price are known and, consequently, the magnitude of the difference which will be exported or imported at each local price is also known. Given these trade functions and transportation costs, we wish to ascertain: 1) the net price in each region; 2) the quantity of exports and imports for each region; 3) which regions import, export, or do neither; 4) the aggregate trade in each commodity; 5) the volume and direction of trade between each possible pair of regions . . .

Samuelson (1952) showed that the Enke problem contains, in addition to a spatial equilibrium solution, a solution for a minimum transportation cost problem of the type demonstrated by Koopmans (1949). Samuelson (1952) also demonstrated that the solution to the above problem yields the maximum "net social pay-off". Net social pay-off is defined as the sum of the social pay-offs in all regions less transport costs.

Bressler and King (1970) discuss the reasons for regional specialization and, consequently, the benefits of interregional trade. The basis for regional specialization is fundamental differences in production technology and/or costs. Bressler and King give a general production function of the form:

$$Q = q(f_1, f_2, f_3 \ldots, f_n, C_1, C_2, C_3, \ldots, C_m) \tag{2.1}$$

where Q = quantity of output,

f_1 through f_n = economic production factors, and

C_1 through C_m = uncontrollable or climatic production factors.

Climatic factors will vary from region to region. Thus, partial production functions which contain only economic variables will also vary from region to region. The resulting differences, wrote Bessler and King (1970), cause regional specialization because the complex of economic forces ". . . makes it unusually profitable for a number of firms in the region to specialize in the same kind of activity" (p. 56). The result is a need for interregional trade in order to distribute production to points of demand in other regions. Bressler and King observe that the fundamental result of this chain of events (i.e., specialization and trade) is that it allows individuals to increase their satisfaction and welfare.

Spatial Studies of Livestock Industries

Several researchers have applied these basic concepts to the livestock industry. Most approaches used linear programming to optimize the objective function in question. Some approaches involved recursive algorithms.

Judge and Wallace (1960) were among the first to consider the spatial aspects of the U. S. swine-pork industry. Linear programming was employed to minimize transport costs of live hogs and pork from regions with hog or pork surpluses to those with hog or pork deficits. Regions were defined as surplus or deficit by comparing spatial equilibrium demand quantities in each region (determined by linear demand functions) and predetermined supplies. In addition, Judge and Wallace (1960) used comparative statics to find that a quarterly model yielded solutions that differed little from those of an annual model and that the demand for transportation services for pork is highly inelastic. The elasticity of demand for transportation services was investigated by observing the effects of a 20 percent increase in transport costs on optimal shipment patterns. The finding was caused by the insignificance of transport costs relative to the retail price of pork.

Stout and Bentley (1962) used a procedure very similar to that of Judge and Wallace and found that hog production exceeded slaughter capacity in many regions of the South. However, these levels of production were still below the regions' consumption requirements. The 1960 solution, and that for projections for 1975, both confirmed the desirability of production-oriented slaughter because of the decreased total transportation costs of this scheme. Additional conclusions were that favorable conditions with respect to transport costs would remain largely unexploited in the Southeast and that Corn Belt fringe areas could possibly witness slaughter development to levels exceeding local production.

Sprott (1972) used the linear programming transhipment model to solve least cost location and quantity of hog production among 27 regions in the contiguous states in 1971. Sprott pointed out the absence of international trade as a factor in the swine-pork industry, the possibility of depressed prices in a region which experiences rapid growth in production and the fact that the 1960s saw only minor adjustments in production locations and market shares among regions. Sprott concluded that Texas could increase hog production by 253 percent and that the industry closely approximated perfect competition because average total costs were only 2.5 percent below market price at equilibrium levels.

Kelly, McCoy, and Manuel (1961) investigated the possibility of increasing hog production in western Kansas through the application of the model used by Judge and Wallace (op. cit.). The researchers concluded that hog and pork production would increase in the grain sorghum producing regions of the southern Great Plains and that there were substantial advantages to the transport of dressed pork versus the transport of live hogs. The latter of these conclusions implied, once again, the desirability of production-oriented slaughter.

The most recent study of the hog industry's potential in the Southwest was done by Lee and Perrin (1975) and dealt with fixed supplies and demands. Linear programming was used to solve for least-cost interregional flows of live hogs and pork for 1970 and 1975. Both solutions showed that Oklahoma received hogs from Kansas and pork from Nebraska. However, there were more inshipments of pork and less of live hogs in 1975.

Several studies concerning interregional movements of cattle and beef have been completed. All of the studies used linear programming to minimize transport costs, yet all have unique characteristics.

Wallace and Judge (1959) used a model similar to that used in the study of the swine-pork industry previously reviewed to determine spatial equilibrium prices, demand, and trade flows for fed beef. Broadbent and Sullivan (1972) utilized the linear program transhipment model to solve for least-cost shipping patterns and product forms (carcass, primal cuts, or retail cuts) for beef and beef cattle. Again, only fed beef was considered but shrinkage was incorporated in the model at a constant 2.5 percent level. Liu and West (1970) solved for minimum aggregate industry costs in the South's beef cattle industry by using a linear programming model. The model assumed supplies and demands to be fixed but incorporated two products, fed and non-fed beef, into its framework. Resources and slaughter services were assumed to be in perfectly elastic supply up to a defined capacity in each region.

A linear programming transhipment model similar to that used by Sprott (op. cit.) was used to study the fed cattle-fed beef sector by Williams and Dietrich (1966). The study solved for least-cost flows to fulfill spatial equilibrium demand requirements under several assumed circumstances. Regional differences in slaughter costs received particular emphasis. Due to data limitations, however, slaughter costs were based only on wage rates and slaughter plant output.

Dietrich (1971) again used the model developed in collaboration with Williams to look at the cattle feeding economy with emphasis placed on economies of size. Dietrich concluded that increases in the size of Northcentral cattle feeding operations to 5,000 head would be beneficial from a cost efficiency standpoint. In addition, his conclusions substantiated previous findings that total production and distribution costs are minimized if the cattle feeding industry is located in the Southern Plains, New Mexico-Arizona, Colorado, Kansas-Nebraska, and Central Corn Belt regions. Projections for 1975 indicated a continuation of this advantage but also suggested the emergence of Kentucky-Tennessee as a major feeding area for cattle.

Mathematical Techniques

Since its application to economics in the 1940s, linear programming and its variant forms have enabled many researchers to look at complex systems with relative ease. This study uses two mathematical routines: a linear programming transhipment model and reactive programming. The first is a special case of linear programming while the later contains a transportation problem.

Reactive programming is designed to simultaneously calculate equilibrium production and consumption levels as well as interregional flows (Seale and Tramel, 1965). It utilizes downward sloping demand functions, upward sloping or perfectly inelastic (fixed) supply functions, and constant per unit transport costs in calculating spatial equilibrium supply and demand quantities, interregional trade flows, and prices. Tramel and Seale (1959) applied reactive programming to Mississippi fresh vegetable markets and effectively demonstrated its capabilities.

While being a very fine analytical tool, reactive programming (in its basic form) is somewhat limiting in that it allows researchers to view only one level of a marketing chain. Hurt (1970) expanded the basic model to allow for processing of a raw product and transhipment of the final product but found it necessary to group the costs of some levels of the marketing system. The aggregation of costs caused a lack of model specification and made interpretation more difficult.

Another adaptation of reactive programming was made to consider the fluid milk industry (Riley and Blakley, 1976; Riley, 1974). The Riley and Blakley version aggregates the farm supply function, processing costs and retailing costs in each region to obtain a retail supply function for fluid milk. In addition, it considered fluid milk utilization percentages and support prices explicitly and demonstrated the flexibility attainable through reactive programming. Riley (op. cit.) also included several "tricks" that greatly reduced the computer time necessary for solving such problems.

King and Ho (1972) discussed input and time requirements and several example applications of yet another modified version of reactive programming. The King and Ho version contains a linear programming subroutine to compute initial product allocation (unless specified) and allows the obtainment of printouts for intermediate solutions.

The linear programming transhipment model has been widely used to investigate problems where intermediate processing or warehousing is necessary. This widespread use is evident within this review. Several authors have written of the model's usefulness not only in solutions to problems but in gaining an understanding of the solution's sensitivity.

Samuelson (1952) discussed the possibilities of ordinary linear programming in spatial studies. His observations and conclusions concerning trade flows and the application of the dual solution to analyses of price relationships also apply to transhipment models. These conclusions, however, are made somewhat more difficult due to the transhipment model's consideration of subsequent levels of a marketing system.

The transhipment model, whether formulated as a linear program or as a common transportation problem, seeks to optimize an objective function. In most cases the objective is to minimize the total costs of transportation. Agrawal and Heady (1972) discuss the nature of such a minimization problem in the context of a least-cost feed mix and list two differences from maximization problems which are applicable to the model used in this thesis. First, the objective function is to be minimized and second, equality constraints are placed on final quantities of feed produced so that the formulation is exact. For problems of a marketing and shipment nature, the latter of these points usually applies to final demand quantities.

Beneke and Winterboer (1972) addressed specific points of model characteristics. The authors demonstrated the use of transfer rows in a linear programming tableau to move product from sector to sector. Separate activities were constructed for all possible shipments and total costs to fulfill demands in all regions were minimized by the example model. Demand requirements were represented by equality constraints.

King and Logan (1964) used a standard transhipment model, i.e., not constructed in linear programming format, to solve for optimal beef slaughter plant locations. In addition to determining locations, the model was used to evaluate optimal slaughter plant size by using an iterative technique involving adjustments of slaughter costs in regions in accordance with the number of cattle slaughtered.

CHAPTER III

THEORY AND THE MODEL

The theoretical basis and computational model used in this study are discussed in this chapter. Each topic is addressed individually. A relatively simplified empirical example is presented at the end of the chapter to demonstrate both the computational model and the theory upon which it is based.

Theory

Spatial Equilibrium

The underlying causes of regional specialization and interregional trade were detailed in the review of literature. Several authors (Samuelson, 1952; Judge and Wallace, 1960; and Bressler and King, 1970) have addressed spatial equilibrium theory and given diagramatical or mathematical proofs of its validity.

The requirements for price-quantity equilibrium among spatially separated markets are very simple. For any pair of such markets activity engaged in trade (i.e., shipments are taking place), the difference between the equilibrium prices in the two markets must equal the cost of transporting the product in question from one market to the other. In mathematical terms, this is shown by:

$$P_i - P_j = T_{ij} \tag{3.1}$$

where P = price per unit in markets i and j, i, j = 1, ..., n, and $i \neq j$, and

T_{ij} = per unit transport costs from market i to market j.

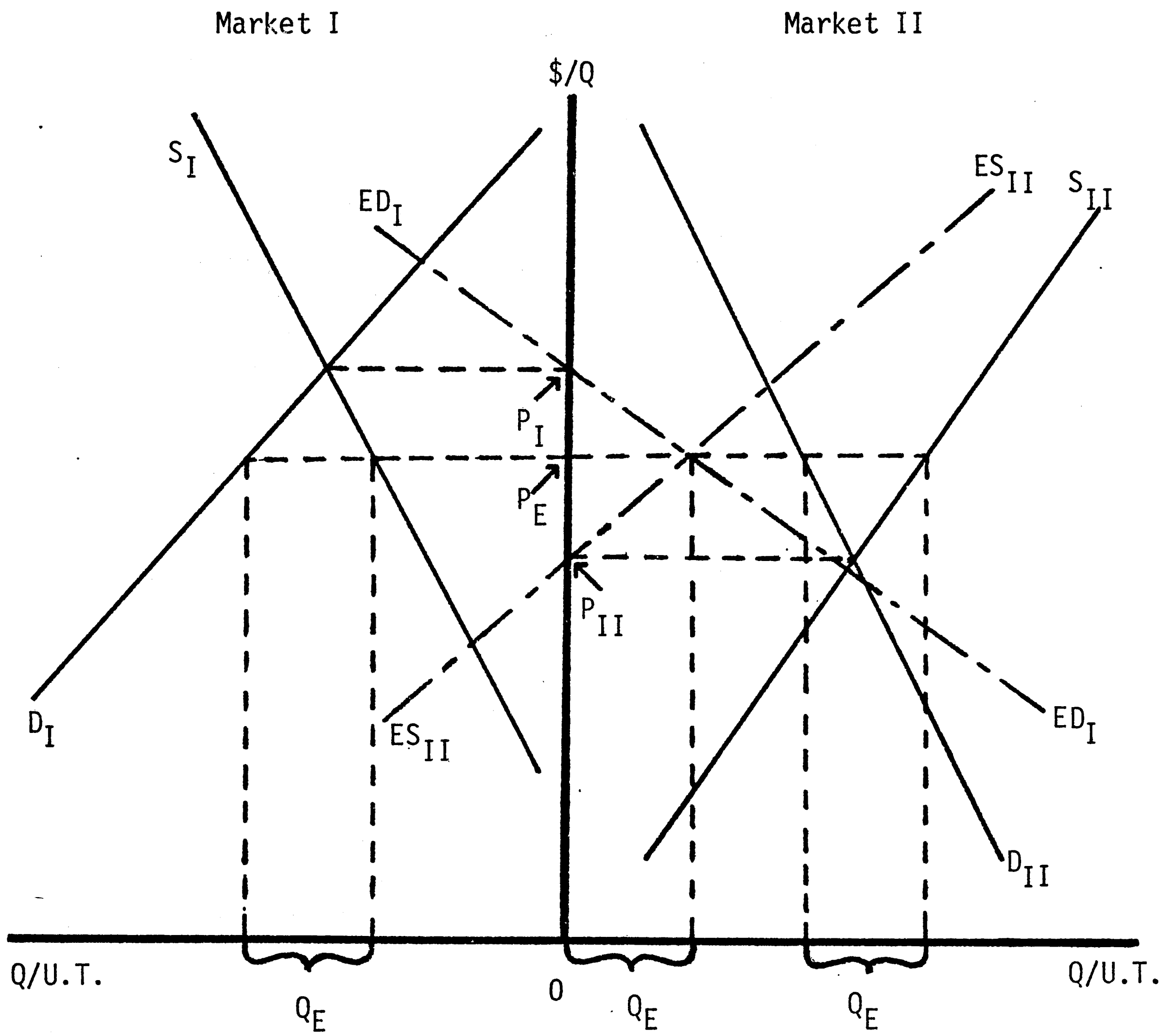
In addition, spatial equilibrium requires that price differences between any pair of markets not involved in trade must be less than the amount of transport costs. This is represented by the equation

$$P_i - P_j < T_{ij} \tag{3.2}$$

where P and T are as previously defined.

The condition depicted by equation 3.1 is shown graphically in Figure 1. In this figure, two markets (I and II) are separated, but not isolated. Transport costs between the markets are assumed to be zero. At the original equilibrium prices of P_I and P_{II} there exist incentives for producers in market II to sell product in market I and for consumers in market I to purchase product in market II. These incentives are due to a difference in intra-market equilibrium prices ($P_I - P_{II}$) that exceeds transport costs (zero). As units of product are shipped from market II to market I, relative price levels change and will continue to do so until P_E is reached. At P_E, P_I is equal to P_{II}, the difference in market prices is zero (the amount of transport cost), and the condition specified by equation 3.1 is fulfilled.

The spatial equilibrium price and quantity shipped are determined by the intersection of the markets' excess supply and demand curves. A market's excess supply curve shows the amount by which the quantity offered for sale exceeds the quantity which would be purchased at various prices above the intra-market equilibrium price. Conversely, a market's excess demand curve shows the amount by which the quantity demanded exceeds the quantity supplied at various price levels below



Source: Judge and Wallace, 1959.

Figure 1. Spatial Equilibrium for a Two Market Case with Zero Transport Costs

the intra-market equilibrium price. These are portrayed in Figure 1 by ED_I and ES_{II}. The quantity shipped from II to I is Q_E. Q_E represents the amount of excess supply in market II and the amount of excess demand in market I at the spatial equilibrium price of P_E.

The effect of non-zero inter-market transportation costs can be seen by examining Figure 2 which portrays ED_I and ES_{II} as shown in Figure 1. Since the cost of a unit of product received by consumers in market I from producers in market II is higher than the supply price in market II by T, the amount of transportation costs, the curve ES_{II} must be shifted upward by T for all quantities. The new excess supply curve is ES'_{II}. The new equilibrium inter-market trade quantity is Q'_E and spatial equilibrium prices are P'_I and P'_{II}. The difference between these prices is T and thus the condition set forth by equation 3.1 has again been fulfilled.

The difference between ED_I and ES_{II} can be characterized as a demand for transfer services as it reflects the quantity of market II supply that will be demanded in market I at alternative costs of transport. The line NN in Figure 2 represents such a demand for transfer services function. The line YZ represents a horizontal function for the supply of transfer services since the transportation cost, T, is assumed to be constant for all levels of trade. The equilibrium quantity of transfer services for any level of transport costs is identical to that found in the analysis of market excess supply and demand curves.

If 1) the difference between ED_I and ES_{II} was smaller so that the line NN intersected the vertical axis at or below Y, or 2) inter-market transport costs were greater than OG, no inter-market trade would occur.

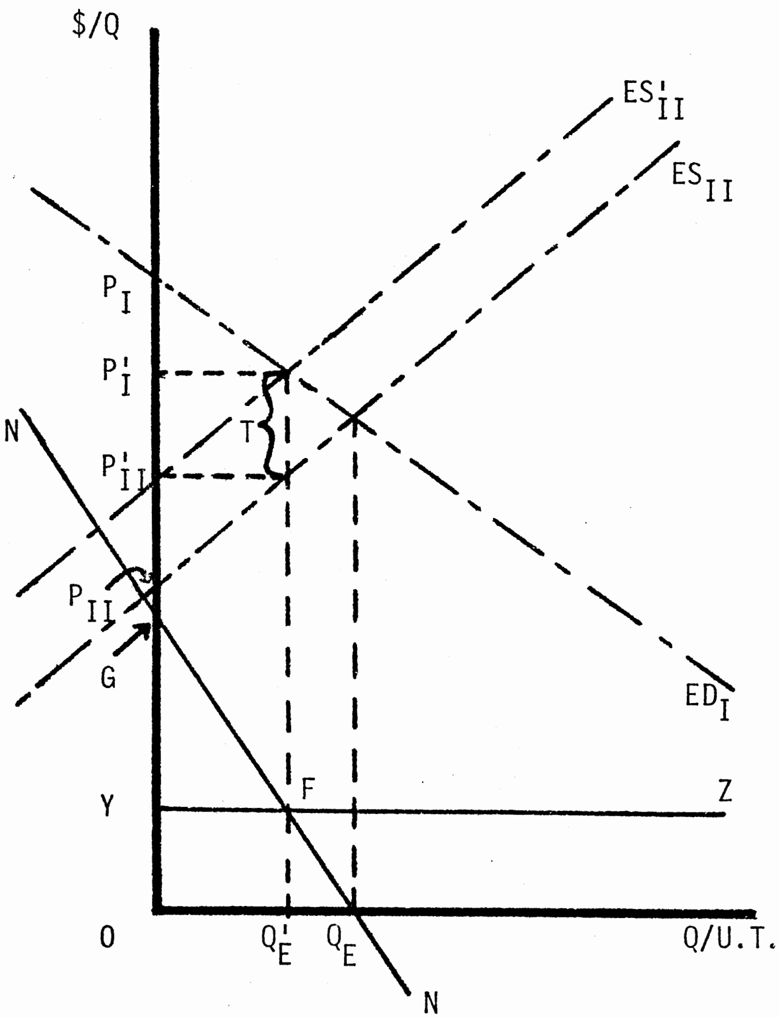


Figure 2. Spatial Equilibrium with Non-Zero Transport Costs

In either of these circumstances, the price difference would not exceed transport cost at a trade quantity of zero and thus the incentives noted in the discussion of Figure 1 would not exist. This is the situation depicted by equation 3.2.

In any system containing more than two markets, both of the above conditions may exist at a given time. When price differences between all possible pairs of markets fall into one of these two categories, spatial equilibrium has been achieved.

Samuelson (1952) presented a diagramatical proof that spatial equilibrium maximizes "net social pay-off." This proof is also shown by Figure 2. Net social pay-off (NSP) is defined as:

NSP = Total social pay-off in market I + Total social pay-off in market II - Transportation costs.

The total social pay-off for the jth market (TSP_j) is the area under its excess demand curve. This area is equal in magnitude to the area under the region's excess supply curve but opposite in sign. Since inter-market transport costs are greater than zero, ES'_{II} is the effective excess supply function for market II and the area under ES'_{II} is the negative of TSP_{II}. By adding TSP_I (positive) and TSP_{II} (negative), the combined social pay-off for the market system is obtained. The line NN represents combined social pay-off.

When total transport costs at Q_E (OQ_EFY) are deducted from the combined social pay-off at Q'_E (OQ'_EFG), net social pay-off is derived. This net social pay-off is the area of the triangle FGY which represents the maximum net pay-off attainable for the depicted situation.

Consideration of the relative values of the units transported from market II to market I in Figure 2 will also lead to the conclusion that spatial equilibrium maximizes net social pay-off. The first unit of product transferred from market II to market I has a value of P_{II} in its production area and a value of P_I in the consumption area. It is clear that this movement to the higher-value market represents an increase in welfare to society. This gain continues until P_I' and P_{II}' are reached with Q_E' being exported from market II to market I. By deducting total transportation costs $(Q_E' \cdot T)$ from this net increase in social welfare, Samuelson's net social pay-off is deduced through a purely logical approach. This approach assumes that there is no difference in the "worthiness" of either market's consumers.

Cost Theory and Supply Response

The supply function for any product is determined by the marginal cost functions of individual producers.[1] The relevant portion of these marginal cost functions with respect to the determination of a product's supply function is dependent upon the time period in question. Since this study seeks to determine long-run expansion potential, the question of supply function determination from the long-run point of view is addressed.

In the long-run, the portion of the individual producer's marginal cost curve which is relevant to the supply function is that part lying above long-run average costs. In Figure 3, this is the portion of the curve LMC above P'. The horizontal summation of all such individual supply functions determines the supply function for the sector in

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[1]For a diagramatical presentation of this theory, see Leftwich (1976).

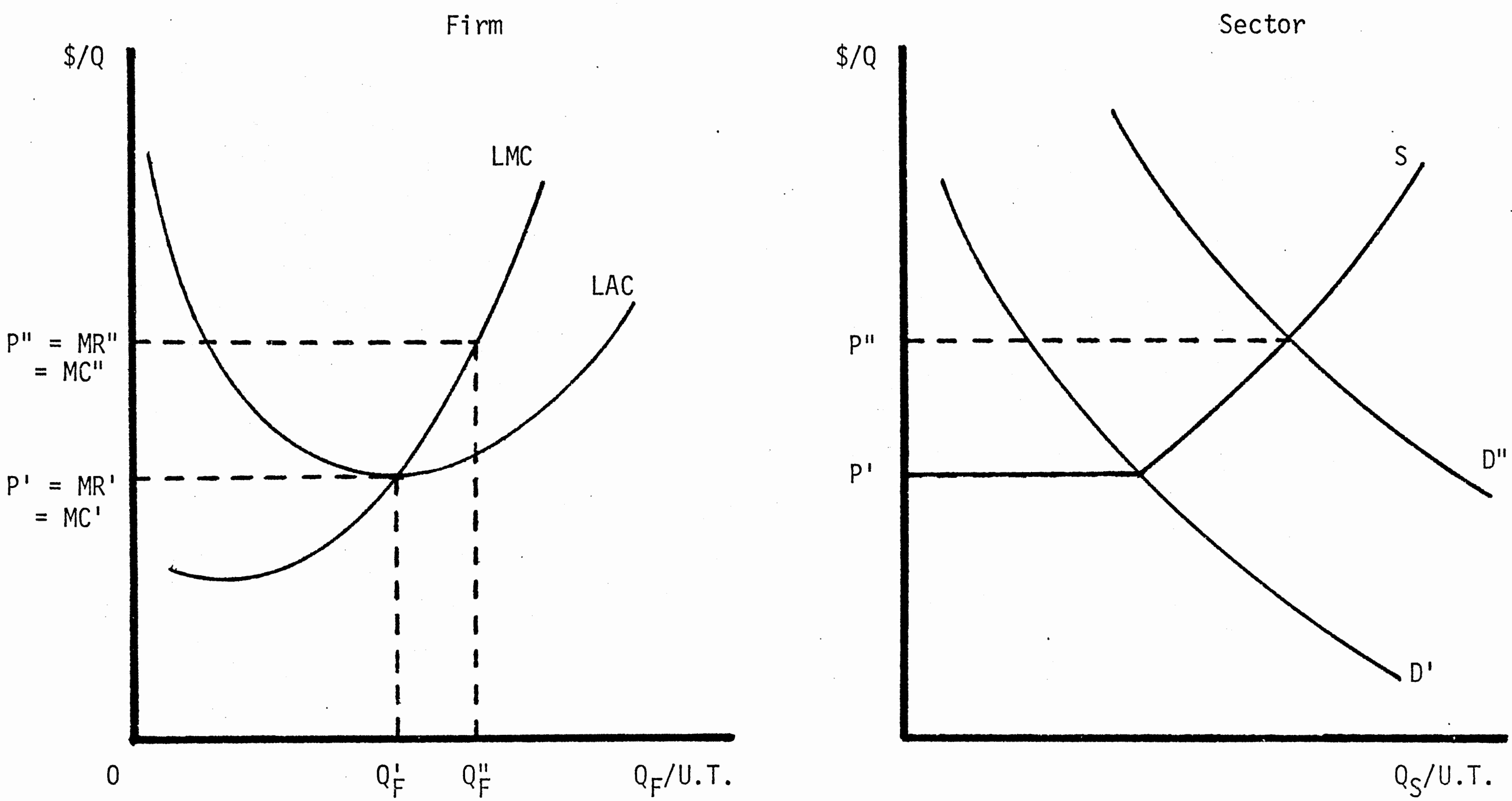


Figure 3. Firm and Sector Supply Response Assuming Static Cost Structures

question, whether it be an entire industry, a region, or a single market. The sector's supply curve is represented by S in Figure 3, assuming that the aggregate cost structure of the sector is static.

The assumption of a static aggregate cost structure (and thus a static supply function) for the sector is very important to this analysis. It implies that "long-run" be defined as a period of time long enough for producers to adjust output but short enough to prevent the construction of new production facilities by new or existing firms.

An analysis of the behavior of the firm depicted in Figure 3 will explain the relationship between costs and output. Assume that perfect competition exists in the market for product Q, that price and quantity adjustments are instantaneous, and that the firm is originally producing Q' in response to a price of P'. P' is determined by the intersection of the market supply (S) and demand (D') functions. Note that, at this output, P' = MR' = MC' so profits are being maximized. Now consider the firm's response to a price of P" which is caused by a shift of the market demand function to D". Output increases to Q_F'' where P" = MR" = MC". Since MC and Q_F increase together, a positive relationship exists between costs and output over the range of the firm's supply function. If all firms in a sector behave so as to maximize profits (and this is assumed to be true), then the positive cost-output relationship described above for the individual producer's supply curve is also true for the market supply curve.

By re-defining "long-run" to allow sufficient time for additional production facilities to be constructed by either new or existing firms, the assumption of static cost structure in the sector can be relaxed. This situation is shown in Figure 4. In this case, producers

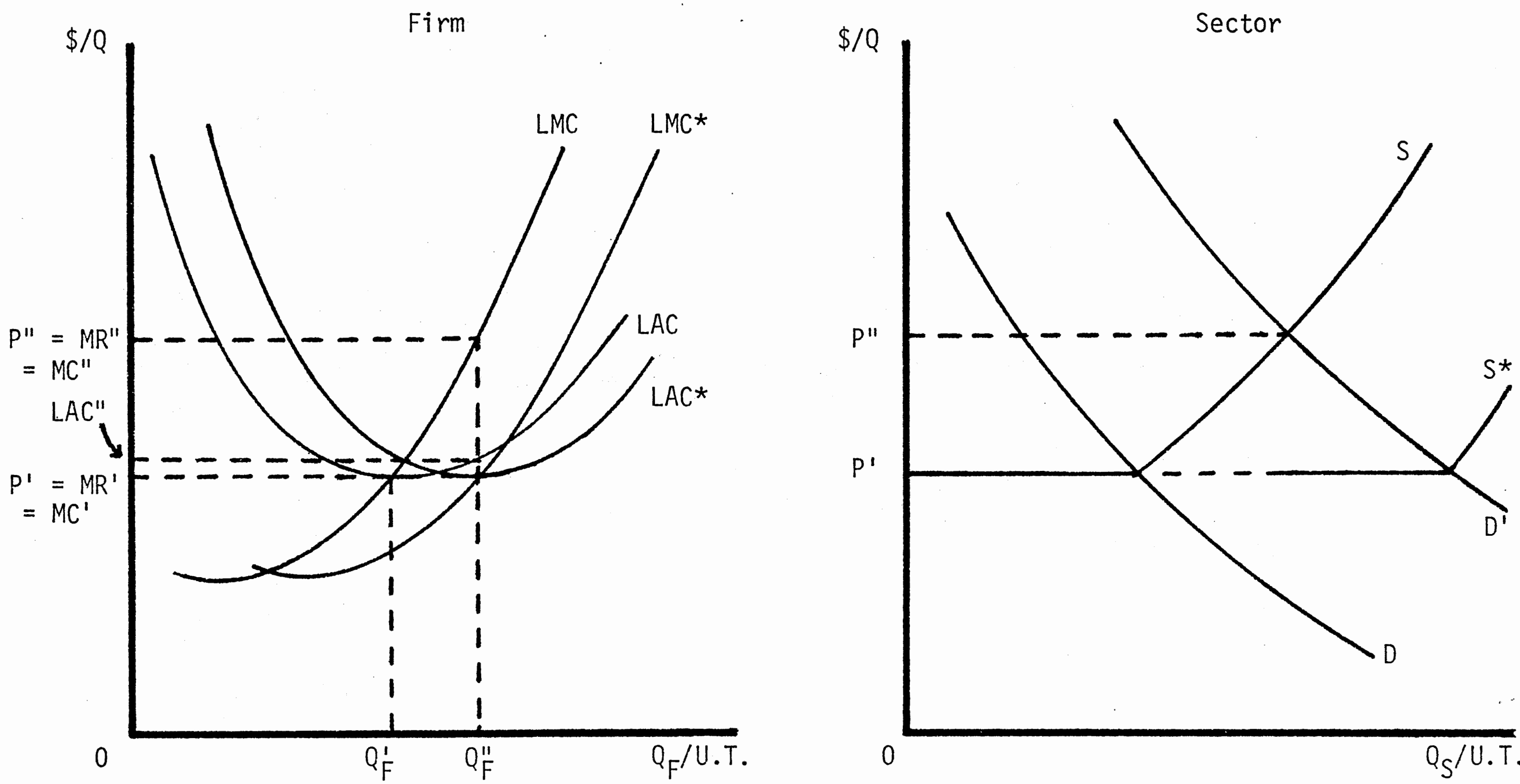


Figure 4. Firm and Sector Supply Response Assuming Non-Static Cost Structures

again respond to the price P" be increasing production to Q_F'' at which economic profits in the amount of $P'' \cdot Q_F'' - LAC'' \cdot Q_F''$ are being realized. The possibility of higher-than-average returns (average returns are considered a component of long-run average costs) attracts investors to build new production facilities. This new investment causes the firms' cost functions (investment is assumed to occur in established firms) to shift rightward to LAC* and LMC* which, in turn, causes the sector's supply function to shift rightward to S*. The net effect of this shift is that a new long-run equilibrium for each firm is established at Q_F'' and P'.

From these analyses, it can be seen that at any one point of long-run equilibrium in a perfectly competitive market, price, marginal costs and average costs are equal. By nature of these equalities, the elasticity of supply can be employed to estimate the nature of the market supply function.

The elasticity of supply is defined as the percentage change in output elicited by a one percent change in price. In mathematical terms, this is presented as

$$E_s = \frac{\partial Q}{\partial P} \cdot \frac{P}{Q} \qquad (3.3)$$

where E_s = elasticity of supply,

Q = quantity supplied, and

P = price.

Assuming instantaneous adjustment of prices and quantities in a perfectly competitive model, the profit maximizing condition of equality among prices, marginal revenue, and marginal cost will always hold. Thus, equation 3.3 can be restated as:

$$E_s = \frac{\partial Q}{\partial LMC} \cdot \frac{LMC}{Q} \tag{3.4}$$

or

$$E_s = \frac{\partial Q}{\partial LAC} \cdot \frac{LAC}{Q} \tag{3.5}$$

Equations 3.4 and 3.5 allow supply functions to be computed by using estimates of long-run marginal or average costs. Such a procedure will be discussed in the next chapter.

The Model

The computational model employed used in this study involves reactive programming and a linear programming transhipment model. This discussion concerns the characteristics of these algorithms, their combination and interaction, and an example of how the prescribed method works in a simplified situation.

Reactive Programming

Reactive programming was developed by Tramel and Seale (1965) at Mississippi State University. The version used in this study was designed by King and Ho (1972) at North Carolina State University. The assumptions of the particular model employed in this study are:

1. Perfect competition exists in the pork market.
2. The objective of all shippers of pork is to maximize net revenues.
3. Products and loads are perfectly divisible.
4. Transfer costs represent <u>all</u> costs between the points of origin and destination of a shipment.

5. The supply source and market for each geographical region are represented by a single point.

6. The product is homogeneous (i.e., consumers are indifferent as to the origin of product).

7. The total supply of pork is equal to total demand for pork.

The explicit objective of the reactive program is to maximize the net revenues of all producers of pork (henceforth referred to as slaughterers) subject to the conditions for spatial equilibrium. This objective can be mathematically stated as:

Maximize:

$$Z = \sum_{j=1}^{m} \sum_{k=1}^{n} Q_{jk}(P_k - C_j - MT_{jk}) \qquad (3.6)$$

Subject To:

$$\sum_{j=1}^{m} Q_{jk} = \sum_{k=1}^{n} Q_{jk} \quad ; \quad Q_{jk}, P_k, C_j \geq 0$$

where Z = total net revenues for slaughterers,

j = slaughter region, $j = 1, \ldots, m$,

k = consumption region, $k = 1, \ldots, n$,

Q_{jk} = quantity shipped from the jth slaughter region to the kth consumption region,

P_k = price in the kth consumption region, $P_k = f(\sum_{j=1}^{m} Q_{jk})$,

C_j = cost in the jth slaughter region, $C_j = P_k - MT_{jk}$ for any pair of regions, j and k, engaging in trade, and

MT_{jk} = transport cost per unit from the jth slaughter region to the kth consumption region.

The attaintment of the objective stated in equation 3.6 will occur only when spatial equilibrium is reached in the pork market since, under any other situation, there exist incentives for slaughterers to re-direct pork shipments to higher-value markets. Therefore, two "implicit" objectives of reactive programming may be derived by considering equations 3.1 and 3.2 and Samuelson's proof that spatial equilibrium minimizes total transport costs. These objectives are:

Solve for regional prices such that:

$$P_k - P_j = MT_{jk} \tag{3.7}$$

Subject To:

$$P_j,\ P_k \geq 0$$

where P_j = price in the jth slaughter region, and

P_k and MT_{jk} are as previously defined

and

Minimize:

$$X = \sum_{j=1}^{m} \sum_{k=1}^{n} MT_{jk} \cdot Q_{jk} \tag{3.8}$$

Subject To:

$$\sum_{j=1}^{m} Q_{jk} = \sum_{k=1}^{n} Q_{jk} \quad ; \quad Q_{jk} \geq 0$$

where X = total meat transport costs, and

MT_{jk} and Q_{jk} are as previously defined.

This specific application of reactive programming incorporates unique demand functions of log linear form. The demand functions can be represented as:

$$Q_k^D = \alpha_k P_k^{\beta} \tag{3.9}$$

where Q_k^D = quantity demanded in the kth consumption region,

α_k = the scale factor for the kth consumption region,

β = the own-price elasticity of demand, and

P_k is as previously defined.

The program requires that demand functions be stated in price-dependent form. By algebraic rearrangement, equations of the form

$$P_k = (\frac{1}{\alpha_k} \cdot Q_k^D)^{1/\beta} \tag{3.10}$$

were obtained to be incorporated into the model as input.

Log-linear demand functions have several helpful characteristics. First, their use allows the calculation of demand functions through the use of one quantity and one price for each region and thus gives a common basis for functions in all regions. In addition, the statistical problems of estimating unique regional demand functions and transforming time-series data are avoided (Wold and Jureen, 1953). These functions assume that the elasticity of demand is constant for all quantities. Furthermore, this study assumes that one estimate of the elasticity of demand (β) is applicable to all regions.

Supplies of pork are assumed to be fixed for each run of the reactive program. Supply functions for each run are thus assumed to be perfectly inelastic. Determination of the levels of these supplies will be discussed in a subsequent section.

Linear Programming Transhipment Model

The linear programming transhipment model developed for this study depicts each level of the swine-pork marketing chain from live production through meat shipments from slaughter regions to consumption regions. The model contains costs for each activity and allows for the shrinkage of live hogs in transport and for the transformation of the product from live to carcass form.

The assumptions of the transhipment model are:

1. Additivity of activities and resources.
2. Linearity of the objective function.
3. Non-negativity of decision variables.
4. Divisibility of activities and resources.
5. Finiteness of the solution.
6. Proportionality of activity levels to resources.
7. Single-value expectations.
8. The product is homogeneous.
9. Transport costs represent all costs between the points of origin and destination of a shipment.
10. The supply source and market for each geographical region are represented by a single point.
11. Total live production, total slaughter, and total consumption are proportionately equivalent.

The objective of the transhipment model is to minimize the total cost of production, live shipment, slaughter, and meat shipment necessary to fulfill demands in all regions. In mathematical terms, this is stated as:

Minimize:

$$Y = \sum_{i=1}^{l} (PC_i \cdot Q_i^P) + \sum_{i=1}^{l} \sum_{j=1}^{m} (LT_{ij} \cdot Q_{ij}) + \sum_{i=1}^{l} \sum_{j=1}^{m} (SC_j \cdot Q_{ij} (1 - S_{ij})) + \sum_{j=1}^{m} \sum_{k=1}^{n} (MT_{jk} \cdot Q_{jk}) \tag{3.11}$$

Subject To:

$$Q_i^P \gtreqless F_i^P \; ; \; \sum_{i=1}^{l} Q_{ij}(1 - S_{ij}) \leq SCAP_j \; ; \; \sum_{j=1}^{m} Q_{jk} = Q_k^D \; ;$$

$$Q_{ij}, Q_{jk} \geq 0 \; ; \; \sum_{i=1}^{l} Q_i^P \sim \sum_{i=1}^{l} \sum_{j=1}^{m} Q_{ij}(1 - S_{ij}) \sim \sum_{k=1}^{n} Q_k^D$$

where Y = total cost of carcass pork in consumption regions,

i = production region, $j = 1, \ldots, l$,

PC_i = cost of production per unit in the ith production region,

Q_i = quantity of live hogs produced in the ith production region,

LT_{ij} = live transport costs per unit for shipments from the ith production region to the jth slaughter region,

Q_{ij} = quantity of live hogs shipped from the ith production region to the jth slaughter region,

SC_j = slaughter cost per unit in the jth slaughter region,

S_{ij} = percent shrink of live hogs shipped from the ith production region to the jth slaughter region,

F_i^P =production constraint level in the ith production region,

$SCAP_j$ = slaughter capacity in the jth slaughter region,

Q_k^D = demand requirements in the kth consumption region, and

j, k, Q_{jk}, and MT_{jk} are as previously defined.

The transhipment model contains equality constraints for consumption in all regions. This feature implies perfectly inelastic demand functions. The determination of the consumption levels will be discussed in detail in a subsequent section.

The model assumes that the quantity of live hogs produced (Q_i^P) in selected regions is fixed. This assumption is accomplished by the inclusion of equality constraints and non-zero constraint values for the selected regions.

Henry and Rauniker (1965) demonstrated the use of stair-step cost activities to approximate a supply function in a linear program. The transhipment model includes such activities for regions in which production is not required to be a specified amount. The approximated supply functions are similar to that shown in Figure 5. The actual

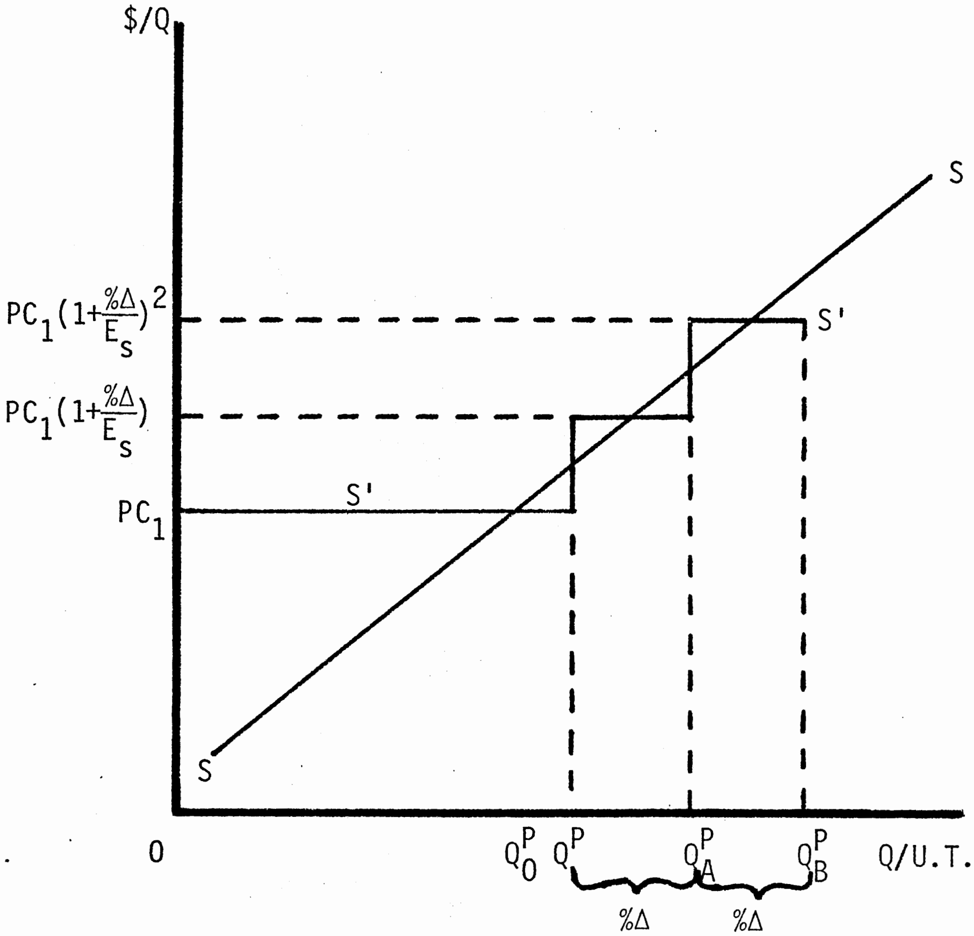


Figure 5. Stair-Step Approximation of a Supply Function

supply function is SS and the approximated function is S'S'. The "original" production activity (up to Q^P) allows for a small increase of live hog production above the estimated original amount (Q_0^P) at the region's base cost per unit. Stair-step production activities A and B (from Q^P to Q_A^P and from Q_A^P to Q_B^P, respectively) allow for successive production increases of specified percentages at successively higher cost levels. The higher costs are determined by the elasticity of supply.

The swine-pork system is assumed to be perfectly competitive and in long-run equilibrium at the original output level Q_0^P. Since

$$E_s = \frac{\%\Delta Q}{\%\Delta P} \tag{3.12}$$

and at long-run equilibrium P = LMC = LAC, it follows that

$$\frac{\%\Delta Q}{E_s} = \%\Delta LAC \tag{3.13}$$

Based on these relationships, estimates of the elasticity of supply for market hogs, average costs and production were used to compute an approximation of a supply function for each variable production region.

Slaughter capacities are included in the model for all slaughter regions by using less-than or equal-to constraints and non-zero constraint values. The constraint values are equivalent to the region's estimated slaughter capacity. The supply of slaughter services in all regions is assumed to be perfectly elastic up to the region's capacity. Thus, slaughter costs are constant in each region for all quantities slaughtered.

The model is easily modified to require certain levels of production and/or slaughter (in addition to consumption) in each region by specifying equality constraints. The modifications allow the consideration of specific situations concerning the spatial distribution of production and slaughter as either separate or simultaneous occurrences. It should be noted that consumption must always be specified due to its "no-cost" position in the transhipment model and the fact that the fulfillment of these demands is the ultimate goal of the system.

A simplified linear programming tableau for a transhipment model of the type used in this study appears in Figure 6. Note that production and slaughter constraint rows (S1, S1A, S1B, and $SCAP_1$, $SCAP_2$ and $SCAP_3$) do not require any certain activity level. A less-than or equal-to constraint places an upper limit upon these rows' respective activities. LT_1 is a transfer row to move hogs from live production activities to live transport activities. Note that the matrix elements for the LT_1 row under live transport activities are $1 + S_{ij}$ (where S_{ij} is as previously defined) and thus cause more pounds of live hogs to be produced than are received by slaughter regions. ST rows transfer live hogs from live transport to slaughter activities and MT rows transfer pork from slaughter to meat transport activities. The matrix elements in MT rows under slaughter activities represent the conversion of one pound of live hog to .62 pounds of carcass pork.

The degree by which this tableau is simplified can be realized by considering that the model actually used in the study contains 259 rows and 1,741 columns in the initial tableau.

Interfacting the Reactive Programming and Linear Programming Transhipment Models

The implementation of the two separate computational algorithms

			Live Production			Live Transport			Slaughter			Meat Transport								
Row	RHS	Type	Q_1^P	Q_{1A}^P	Q_{1B}^P	Q_{11}	Q_{12}	Q_{13}	SL_1	SL_2	SL_3	Q_{11}	Q_{12}	Q_{13}	Q_{21}	Q_{22}	Q_{23}	Q_{31}	Q_{32}	Q_{33}
OBJ		N	PC_1	PC_{1A}	PC_{1B}	LT_{11}	LT_{12}	LT_{13}	SC_1	SC_2	SC_3	MT_{11}	MT_{12}	MT_{13}	MT_{21}	MT_{22}	MT_{23}	MT_{31}	MT_{32}	MT_{33}
S1	X	L	1																	
S1A	Y	L		1																
S1B	Z	L			1															
LT1	0	L	-1	-1	-1	$1+S_{11}$	$1+S_{12}$	$1+S_{13}$												
ST1	0	L				-1			1											
ST2	0	L					-1			1										
ST3	0	L						-1			1									
MT1	0	L							-.62			1	1	1						
MT2	0	L								-.62					1	1	1			
MT3	0	L									-.62							1	1	1
SCAP1	M_1	L							1											
SCAP2	M_2	L								1										
SCAP3	M_3	L									1									
D1	C_1	E										1			1			1		
D2	C_2	E											1			1			1	
D3	C_3	E												1			1			1

Key: X = Primary production constraint
Y = .02(X) = Secondary production activity A constraint
Z = .02(X+Y) = Secondary production activity B constraint
S_{1j} = Percent shrinkage of live hogs transported from production region 1 to the jth slaughter region.
M_j = Slaughter capacity in each region for j = 1, ..., 3
C_k = Consumption requirement in each region for k = 1, ..., 3

L = "Less-than or equal-to"
E = "Equal-to"
N = Non-restricted

Figure 6. General Tableau of the Transhipment Problem Representing One Production Region and Three Slaughter and Consumption Regions

included in the model follows a prescribed sequence. Not all of the study's procedures use both algorithms. Exceptions will be identified in the next chapter. First, the reactive program is solved to determine the pork demand quantities in all regions which fulfill spatial equilibirum price conditions. The distribution of the initial fixed supplies is irrelevant to the determination of these demands. Second, the demand quantities from the reactive programming solution are placed in the transhipment model as consumption requirements. The transhipment model is then solved to determine least-cost patterns of production, live hog shipments, slaughter, and meat shipments. Finally, the least-cost slaughter quantities computed by the transhipment model for all regions are inserted into the reactive program as new fixed supplies of pork. The reactive program is then resolved to verify that the least-cost meat shipment patterns found by the transhipment model actually satisfy spatial equilibrium requirements.

The assumptions of both mathematical algorithms are very similar. The only basic difference is that the assumptions of the reactive program deal only with the pork martket while those of the transhipment model concern the entire system. Thus, the assumptions of the integrated model are stated in those of its component routines. The assumption of no imports to or exports from the 48 contiguous states is implied by the regional demarcation and both model's assumptions of equivalency among quantities at various levels of the swine-pork marketing system.

The existence of spatial equilibrium conditions in the live hog market is not quaranteed by this model. This shortcoming is the result of the necessity of using pre-specified estimates of costs of production as objective function values in the transhipment model. These cost estimates are descriptive in nature and do not attempt to reflect differences which agree with spatial equilibrium theory. The use of "stair-step" supply functions decreases the amount by which actual differences in costs among regions vary from those differences which satisfy spatial equilbrium conditions. However, since production and cost increments along these stair-step functions exceed infinitesimal amounts, spatial equilibrium differences in production costs associated with these activities will not likely be realized.

It should be noted that a degree of disagreement may occur between the meat shipment patterns and/or quantities in the transhipment model's solution and the second reactive program's solution. These disagreements may be caused by 1) a lower specified accuracy level (user-determined) in the reactive program than is automatically required in the transhipment model, or 2) the manner in which the reactive programming algorithm perturbs the matrix of interregional transport quantities so as to compute least-cost flows. The first reason may result in slightly different shipment patterns in the component program's solutions. However, the shadow prices of shipments omitted by either program (as compared to the other) will be very small. The second factor will affect only the transport quantities with such discrepancies being small relative to the quantities in question.

Example

As a demonstration of the model and the sequential employment of its component routines, a simplified example is included. The example is simplified only by virtue of its size and the form of its demand functions. Its activities and constraints are of the same nature as those in the model used for this study. The example's characteristics are as follows:

1. 3 production regions (1, 2, 3)
2. 4 slaughter regions (1, 2, 3, 4)
3. 4 consuming regions (1, 2, 3, 4)
4. Regional demand functions for pork are:

   1 -- $P = 220 - 1.0\ Q$

   2 -- $P = 200 - 2.0\ Q$

   3 -- $P = 230 - 3.0\ Q$

   4 -- $P = 200 - 4.0\ Q$
5. Slaughter costs for region:

   1 -- SC_1 = \$21/unit

   2 -- SC_2 = \$25/unit

   3 -- SC_3 = \$30/unit

   4 -- SC_4 = \$27/unit
6. Slaughter capacities for region:

   1 -- $SCAP_1$ = 50 units

   2 -- $SCAP_2$ = 90 units

   3 -- $SCAP_3$ = 60 units

   4 -- $SCAP_4$ = 40 units
7. Original and stair-step (denoted by A or B) production activity costs and ranges for region:

   1 -- PC_1 = \$95.00/unit when $0 \leq Q_1^P \leq 55$

   PC_{1A} = \$98.80/unit when $55 < Q_{1A}^P < 56.1$

   PC_{1B} = \$102.75/unit when $56.1 < Q_{1B}^P \leq 57.2$

   2 -- PC_2 = \$93.83/unit when $0 \leq Q^P \leq 90$

   PC_{2A} = \$97.58/unit when $90 < Q_{2A}^P \leq 91.8$

   PC_{2B} = \$101.49/unit when $91.8 < Q_{2B}^P \leq 93.6$

$$3 \text{ -- } PC_3 = \$98.27/\text{unit when } 0 \leq Q_3^P \leq 35$$

$$PC_{3A} = \$102.20/\text{unit when } 35 < Q_{3A}^P \leq 35.7$$

$$PC_{3B} = \$106.29/\text{unit when } 35.7 < Q_{3B}^P \leq 36.4$$

A hypothetical map of the four regions appears in Figure 7. The matrices of transportation costs for live and processed product shipments appear in Tables VII and VIII, respectively.

Total industry output is assumed fixed at 180 units for the time period under consideration. Since the example problem contains no provision for shrinkage or product transformation, total slaughter and total consumption are also 180 units. The omission of conversion factors does not decrease the degree by which the example represents the model used in this thesis.

Figure 8 shows a schematic presentation of the shipment patterns found by the interfaced model for this example. The slaughter distribution used to identify fixed supplies of pork in the initial reactive program was computed by distributing total slaughter according to the proportion of total slaughter capacity possessed by each region. The shipment patterns and product flows for the first reactive program solution are shown in Section A of Figure 8.

Demand quantities from the first reactive program are used as constraint values for equality consumption constraints in the transshipment model. The production, slaughter and shipment patterns for the transhipment solution are found in Section B of Figure 8. Note that the slaughter capacity constraint for region one (50 units) is reached in this solution. Primary production activities for all regions are also in the solution at maximum levels. For region one, however, the primary production constraint is not the reason for the production level

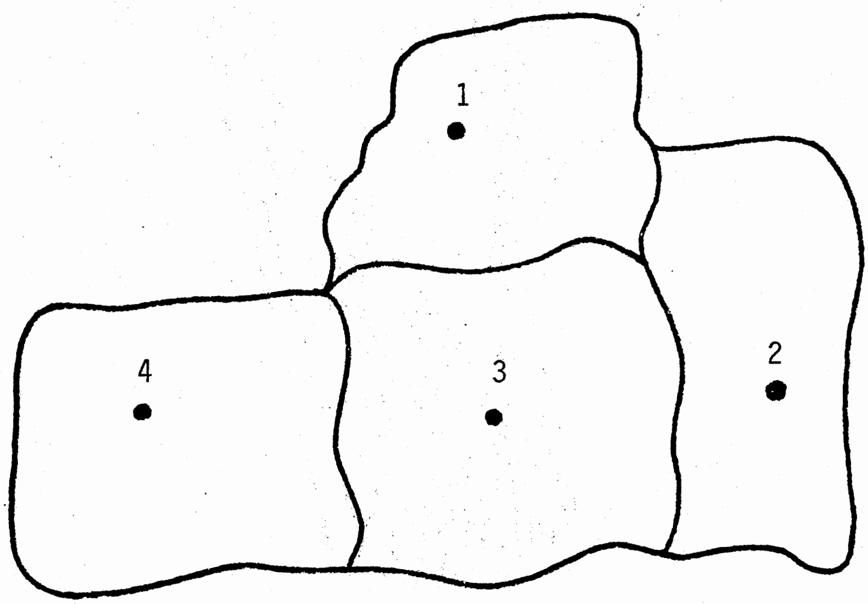


Figure 7. Hypothetical Map of the Regional Demarcation for the Example Problem

TABLE VII

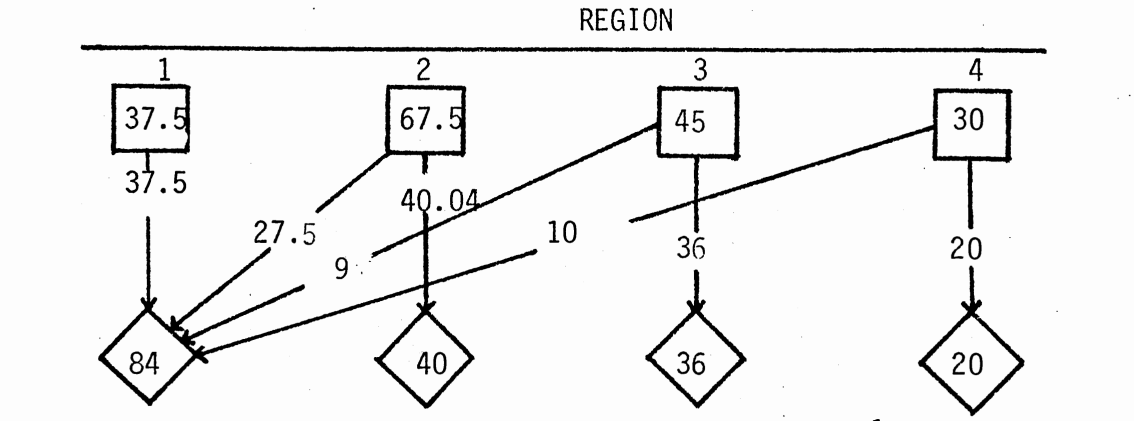
INTERREGIONAL TRANSPORTATION COSTS FOR RAW PRODUCT IN THE EXAMPLE PROBLEM ($/UNIT)

Producing Region	Processing Region 1	2	3	4
1	1	8	7	6
2	8	1	5	6
3	7	5	1	9

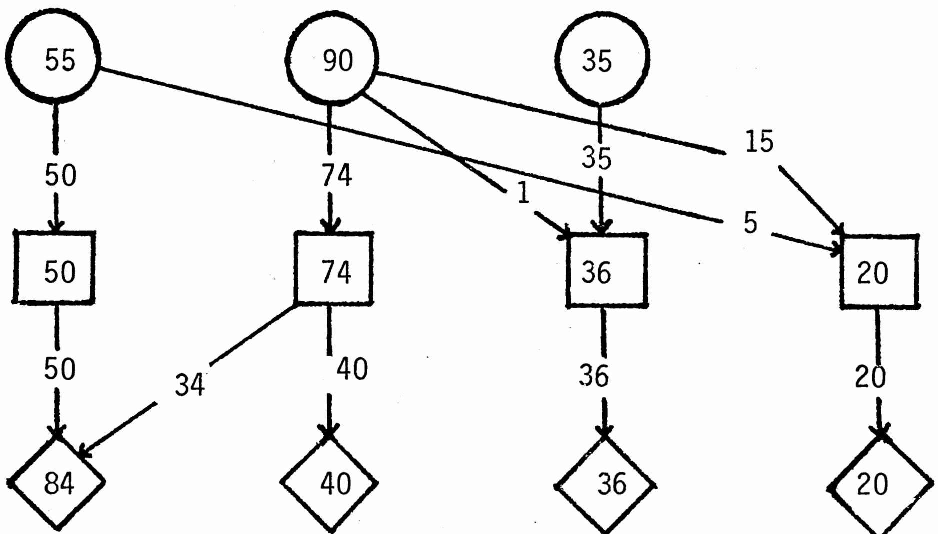
TABLE VIII

INTERREGIONAL TRANSPORTATION COSTS FOR PROCESSED PRODUCT IN THE EXAMPLE PROBLEM ($/UNIT)

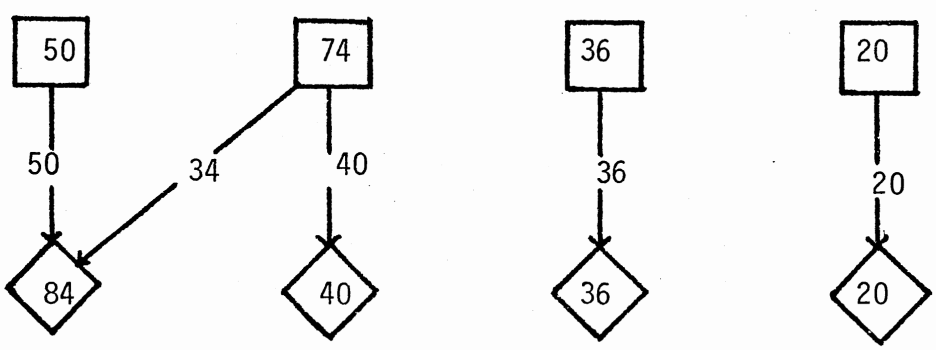
Processing Region	Consuming Region 1	2	3	4
1	1	16	15	14
2	16	1	11	18
3	15	11	1	12
4	14	18	12	1



Section A: Original Processing Distribution.[1]



Section B: Transhipment Model with Demand Quantities from Section A.[1]



Section C: Second Reactive Program Using Processing Quantities from Section B.[1]

[1]Diagram Key: Squares = Processing; Diamonds = Consumption; Circles = Production

Figure 8. Solutions for Model Components for the Example Problem

of 55 units. Region one's production is actually 54.99995 units, a number which is truncated to 55 in the output report. This occurrence is helpful to the analysis of the example problem (discussed in a subsequent section) because it provides different shadow prices for the upper and lower ranges of region one's primary production activity.

Least-cost slaughter quantities are then used as new fixed supply levels for the final reactive program. The shipment patterns for this solution are shown in Section C of Figure 8. Note that the shipment patterns from slaughter regions to consumption regions in Section B and C are identical. This identity means that, by using the integrated model, the least-cost production, slaughter, and shipment patterns that fulfill spatial equilibrium demands for finished product are determined.

The example contains activities for secondary production increases in each region. Higher production costs were computed for two successive increases in production of two percent each. The higher costs are based on an assumed elasticity of supply (E_s) of .50. None of the stair-step production activities are in the optimal solution. If a stair-step activity had been in the solution for any region, the original activity of some other region would have been in the solution at less than its constrained value. This would occur only if the combined costs of obtaining a unit of finished product from a stair-step production activity are less than similar costs of obtaining a unit of finished product via another region's original production activity.

An examination of information found in the RANGE section of the MPSX linear program output for an original production activity yields information with which the degree of expansion potential present in a region can be quantified. The shadow price on the lower range of the primary production activity for region one is \$2.20 per unit. This means that the production costs in region one can increase by any amount less than \$2.20 without affecting the status of the region's original production activity in the solution. The figure of \$2.20 represents a 2.26 percent increase in production costs which corresponds with a 1.13 percent increase in production (recall that $E_S = .50$). Thus, region one may expand production by 1.13 percent (up to 55.62 units) without a shift in its supply function.

Any further increase in production in region one must be the result of an outward shift of the supply function for region one. Such a shift in supply is analygous with a downward shift in the region's aggregate marginal cost function at any given level of output. This downward shift of the marginal cost curve may be brought about by factors such as the construction of new production facilities with cost structures at or below those of existing facilities, new technology, better management, or decreased input prices, assuming all other factors are held constant. The shadow price on the upper range of the primary production activity in region one is \$1.17. This shadow price holds for the range of 55 to 69.52 units. If production costs for additional units of raw product in region one are at least \$1.17 per unit less than the cost of region one's original production activity (\$93.83 vs. \$95.00), production in region one could increase to 69.52 units provided that enough facilities capable of producing at these lower costs are made available. The increase would replace a portion of the production in region two. The analysis assumes that production costs (and thus supply functions) in all other regions remain constant.

The value of additional slaughter capacity in a region can be determined in much the same way as was live production expansion potential. In the solution, region one is at its slaughter capacity of 50 units. The upper shadow price for this constraint is \$20 per unit meaning that additional slaughter capacity in region one would decrease the objective function (total costs) by \$20 per unit. This value is relevant for 5 additional units. Since this \$20 is, in actuality, a return to society on some unknown amount of investment, it should be compared to the opportunity cost of the investment necessary to provide one unit of slaughter capacity. Such an opportunity cost can be computed if estimates of the needed investment and the opportunity rate of return on capital are available.

Appropriateness of the Model

The interfaced reactive programming-linear programming transhipment model provides a great deal of information in a meaningful, forthright format. Solutions garnered from it are logical in an economic sense due to its apparent theoretical correctness. This correctness is attributable to the meshing of the two routines and the way in which they compensate for one another's inherent flaws.

The reactive program can account for only one level of a marketing system because it does not contain a mechanism by which more than one slaughterer can purchase from one producer. This situation is shown in Figure 9. The reactive program views each purchase (Q_1 and Q_2) as unique and computes the raw product supply prices for the purchases as P_1 and P_2. However, the total amount purchased is Q_T and the supply price should be P_T. This shortcoming is overcome by the assumption of

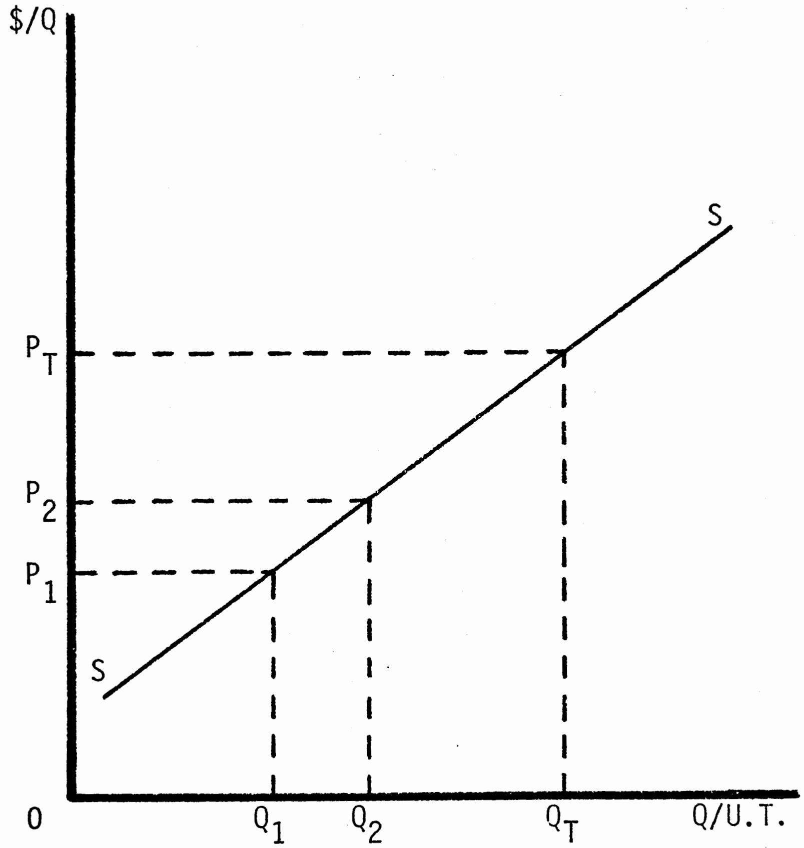


Figure 9. The Single-Level Shortcoming of Reactive Programming

fixed supplies for any particular run and the use of the transhipment model (which views successive levels of a marketing system by design) to establish these supplies so as to minimize costs subject to approximated supply functions for the raw product.

In a similar manner, the assumption of fixed consumption in the transhipment model creates a theoretical flaw in that demand is implied to be perfectly inelastic. However, when the levels of these inelastic demands are determined by the reactive program using its downward sloping demand curves, the theoretical incorrectness of the inelastic demand assumption seems to be markedly decreased. Figure 10 shows the supply-demand relationships depicted by each computational component and the integrated model.

The stair-step supply functions serve as a base to which costs of each successive marketing activity are added to arrive at a generalized supply function for carcass pork. The model does not prescribe a function to which the marketing margin must conform. It is treated as the residual of retail price per pound over actual costs per pound. This, in essence, agrees with a popular view first expressed by Gardner (1975) but does not preclude the incorporation of functions to represent processing and/or transport costs. Such functional costs may be included by using stair-step activities in the transhipment model.

Since the expansion of an entire industry in a region is likely to occur only when such expansion appears lucrative in the long run, the model is long run in nature. This long-run nature is reflected by the use of long-run elasticities of supply and demand. The use of slaughter capacities may appear to conflict with this statement. However, any expansion in slaughtering will occur only in units of an

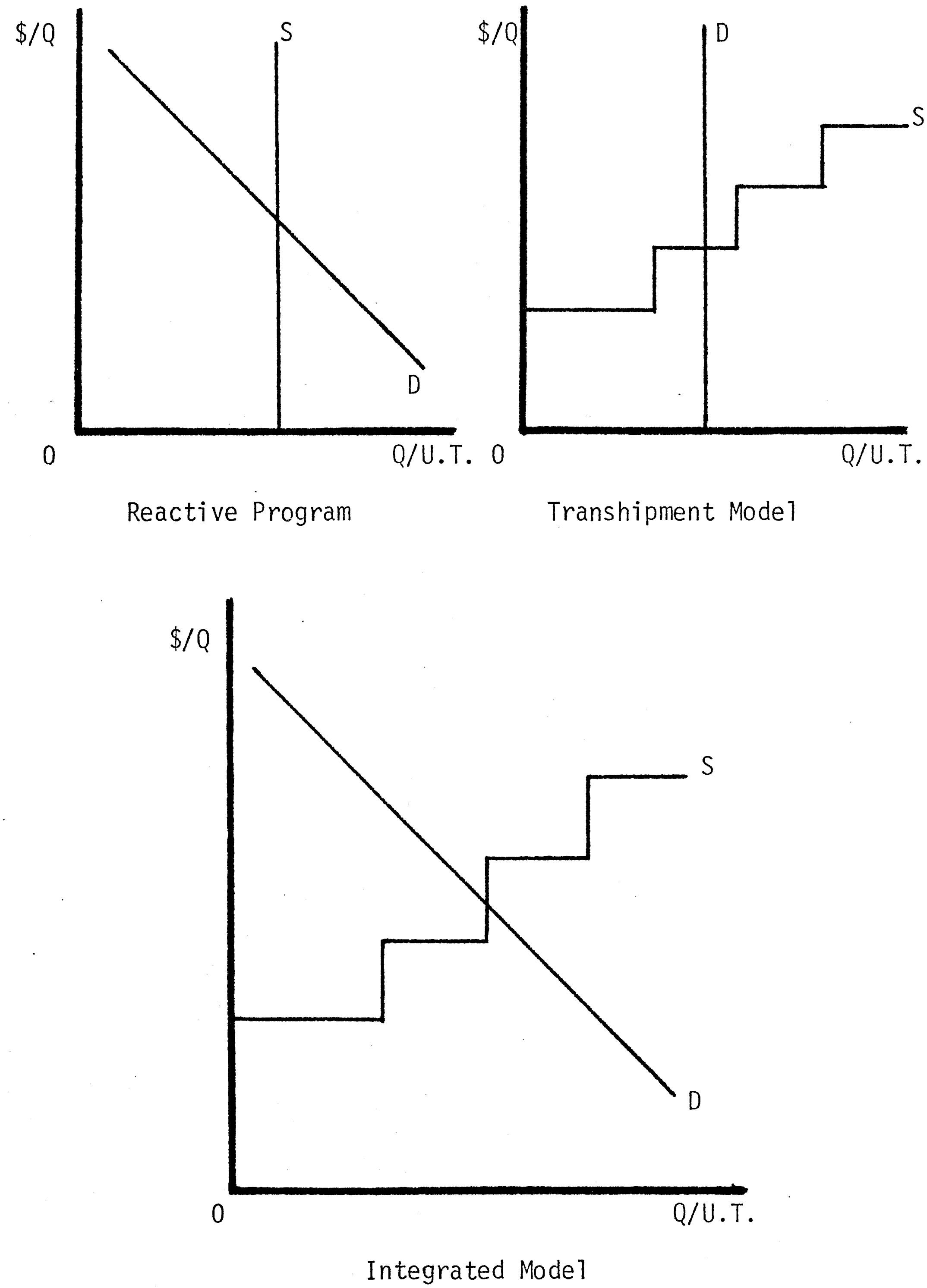


Figure 10. Supply-Demand Relationships Depicted by Each of the Component Algorithms and the Integrated Model

"economically feasible" size. The use of capacities allows the model to 1) determine in which region slaughter expansion is most lucrative, and 2) quantify the possibility of expansion given the necessary investment and possible return per unit.

CHAPTER IV

DATA REQUIREMENTS AND PROCEDURES

Many items of data and several specific procedures were required to address the objectives of this study. This chapter is devoted to 1) a review, discussion and listing and/or calculation of all input data, and 2) a detailed explanation of the procedures outlined in Chapter I.

Data

Regional Demarcation

A map of the regional demarcation employed in the study appears in Figure 11. The demarcation attempts to segregate major production and consumption areas within the 48 contiguous United States. State lines are used as borders of regions due to data being readily available only on a state-wide basis.

The base cities for all regions are shown in Table IX. The selection of base cities is guided by a desire to find a central location within a region with respect to production and/or consumption. Where this goal cannot be met, base cities are selected on the basis of population and conservatism, the latter meaning that major population centers farthest from probable supply points are selected. The underlying reasoning of this criteria is that if shipments occur between two regions over a long distance, then these shipments would surely occur if the distance was shorter.

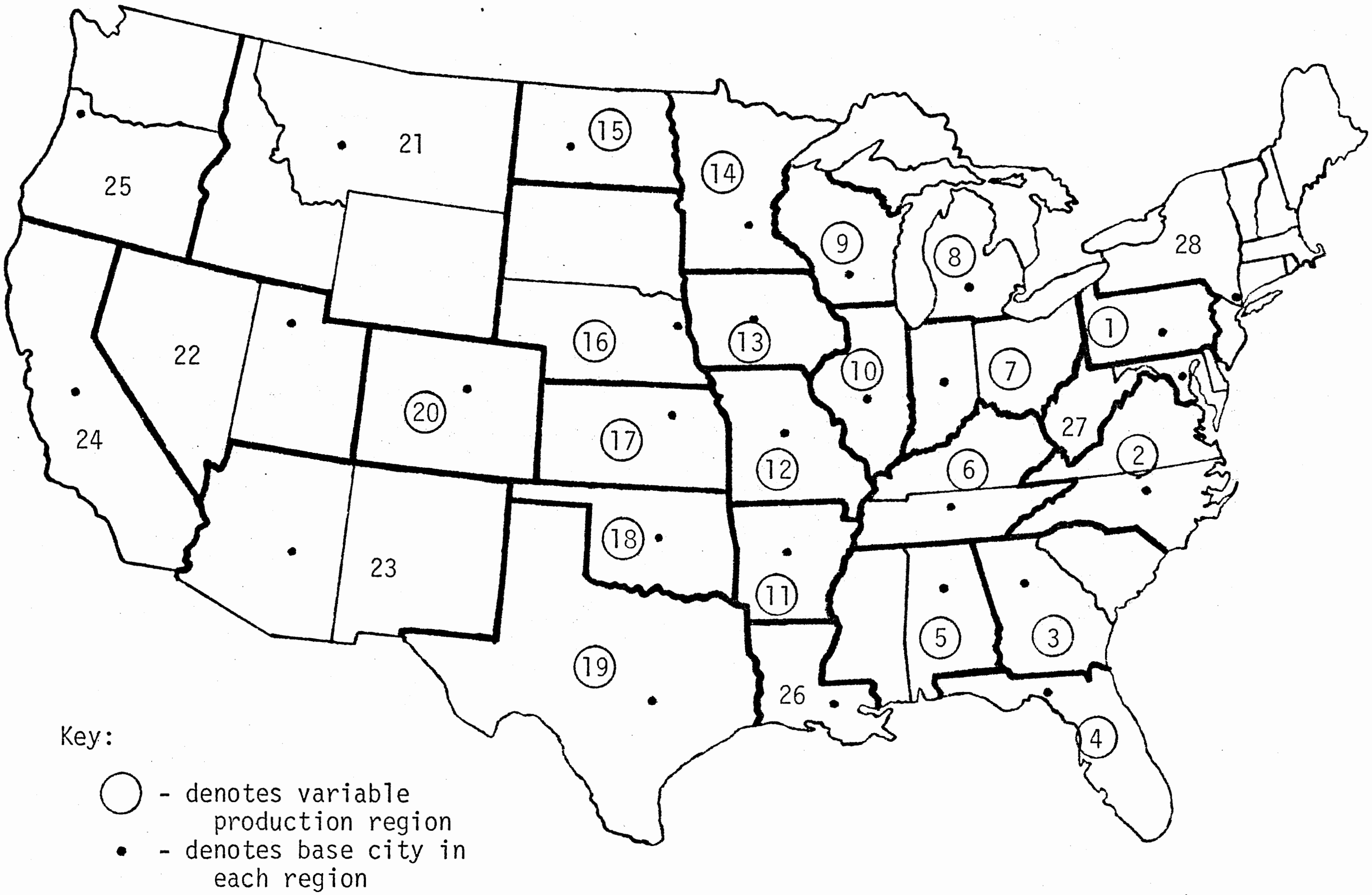


Figure 11. Regional Demarcation of the Contiguous United States

TABLE IX

STATES IN REGIONS AND BASE CITIES FOR REGIONS

Region	State(s)	Base City
1-PA	Pennsylvania	Harrisburg, PA
2-NC	North Carolina, Virginia	Raleigh, NC
3-GA	South Carolina, Georgia	Atlanta, GA
4-FL	Florida	Tallahassee, FL
5-AL	Alabama, Mississippi	Birmingham, AL
6-TN	Kentucky, Tennessee	Nashville, TN
7-IN	Ohio, Indiana	Indianapolis, IN
8-MI	Michigan	Lansing, MI
9-WI	Wisconsin	Madison, WI
10-IL	Illinois	Springfield, IL
11-AR	Arkansas	Little Rock, AR
12-MO	Missouri	Columbia, MO
13-IA	Iowa	Des Moines, IA
14-MN	Minnesota	Minneapolis, MN
15-ND	North Dakota	Bismarck, ND
16-NE	Nebraska, South Dakota	Omaha, NE
17-KS	Kansas	Topeka, KS
18-OK	Oklahoma	Oklahoma City, OK
19-TX	Texas	Austin, TX
20-CO	Colorado	Denver, CO
21-MT	Wyoming, Montana, Idaho	Helena, MT
22-UT	Nevada, Utah	Salt Lake City, UT
23-AR	Arizona, New Mexico	Phoenix, AZ
24-CA	California	Sacramento, CA
25-OR	Oregon, Washington	Portland, OR
26-LA	Louisiana	Baton Rouge, LA
27-MD	West Virginia, Maryland, Delaware, D.C.	Baltimore, MD
28-NY	New York, New Jersey, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, Maine	New York City, NY

The regions are segregated as follows with respect to production, slaughter, and consumption:

1. 20 variable production regions
2. 8 fixed production regions
3. 28 slaughter regions
4. 28 consumption regions

Production, Slaughter, and Consumption Quantities

The model's assumption that production, slaughter, and consumption be equivalent becomes a requirement when viewed from a data standpoint. Due to differences in collection, tabulation, and/or reporting techniques, raw data concerning all statistics are not equivalent. Therefore, a transformation of the raw data is necessary in order to meet the requirement of equivalency at all levels of the marketing system.

The base quantity for transformation is the 1979 total of commercial carcass weight pork production. This quantity is 15.27 billion pounds (U. S. Department of Agriculture, 1980D). The study utilizes 1979 data because these are the most recent available for all needed categories. The base quantity is distributed according to 1979 hog production and slaughter distributions to obtain the regional distributions for these two sectors. These distributions are computed by dividing each region's 1979 production (U. S. Department of Agriculture, 1981D) and slaughter (U. S. Department of Agriculture, 1980E) by total production and slaughter, respectively. The adjusted production and slaughter distributions appear in Table X. Note that the total of

TABLE X

REGIONAL DISTRIBUTION OF BASE-YEAR PRODUCTION AND SLAUGHTER

Region	Production	Proportion of Total	Slaughter	Proportion of Total
	(mil. lbs., live)	(percent)	(mil. lbs., carcass)	(percent)
1-PA	229.0288	.93	525.0351	3.44
2-NC	1096.7030	4.46	875.5285	5.73
3-GA	847.1806	3.45	403.6960	2.64
4-FL	150.0011	.61	20.8779	.14
5-AL	457.6011	1.86	436.2233	2.86
6-TN	1026.1150	4.17	875.6584	5.73
7-IN	2617.2330	10.65	1306.2220	8.55
8-MI	337.4404	1.37	831.4155	5.44
9-WI	650.9060	2.65	366.2438	2.40
10-IL	2848.4160	11.59	1290.6550	8.45
11-AR	223.2821	.91	39.9794	.26
12-MO	1737.7400	7.07	538.2197	3.52
13-IA	5923.9798	24.10	4003.3645	25.25
14-MN	1834.9100	7.46	899.7910	5.89
15-ND	118.9261	.48	4.6896	.03
16-NE	2390.5560	9.72	1333.9200	8.74
17-KS	821.9046	3.34	241.2441	1.57
18-OK	123.7919	.50	190.2771	1.25
19-TX	351.3919	1.43	247.9035	1.62
20-CO	160.5080	.65	80.0307	.52
21-MT	116.3410	.47	93.5026	.61
22-UT	18.8244	.07	21.1150	.14
23-AZ	83.6783	.34	41.5412	.27
24-CA	84.9757	.35	279.6157	1.83
25-OR	75.3660	.31	124.2630	.81
26-LA	43.6428	.18	31.8796	.21
27-MD	112.5888	.46	68.6684	.45
28-NY	102.0667	.42	99.4393	.65
TOTAL	24,483.0333	100.00	15,269.9999	100.00

the regional distribution of production is approximately 1.61 times the total of regional carcass weight slaughter. This factor accounts for the conversion of 1.61 pounds of live hog to 1 pound pork (U. S. Department of Agriculture, 1978B). Discrepancies are due to rounding error.

The distribution of pork consumption in 1979 is computed through the use of 1979 estimates of regional population (U. S. Bureau of the Census, 1980) per capita consumption (U. S. Department of Agriculture, 1980E) and regional consumption indexes for 1978 (Market Research Corporation of America, 1978). The MRCA indexes are for several types of pork including ham, bacon, and fresh pork cuts. Since each of these three cuts comprise approximately one-third of the value of a pork carcass, a simple arithmetic average of the three indexes is used for the regional consumption index. Table XI shows 1979 regional population, adjusted per capita consumption, and the distribution of the base quantity of consumption. Consumption is reported on a carcass weight basis.

Figure 12 shows the regional demarcation for the MRCA consumption indexes. The only conflict between the borders of the MRCA regions and the study regions concerns New York. Region 28 of the study includes New York and MRCA's New England region. Since the indexes for the Middle Atlantic and New England regions in the MRCA survey differed by only .02, the Middle Atlantic index was used for regions 1 and 28 in the study.

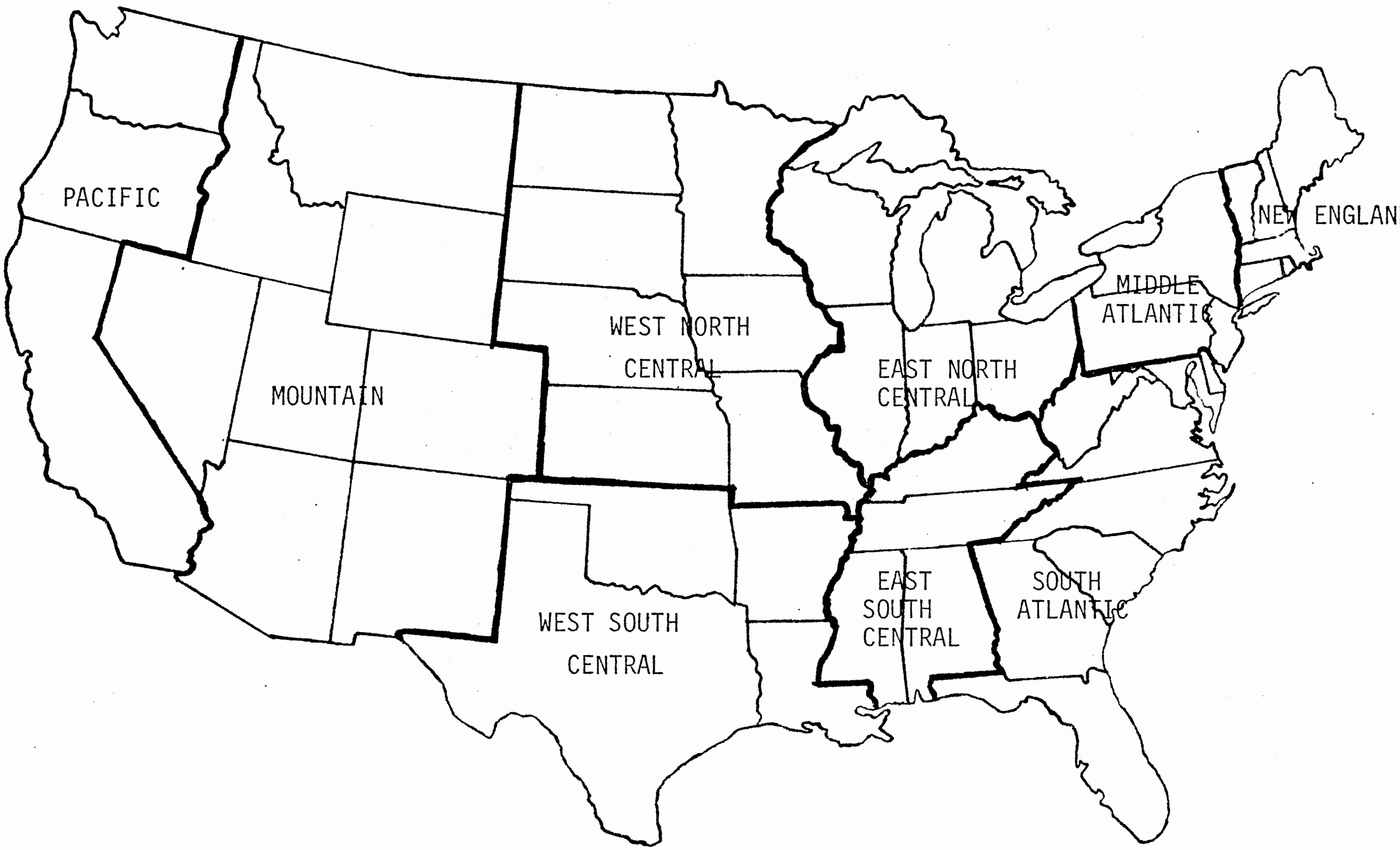
In order to accurately describe the swine-pork industry and compute the cost of pork to consumers, shrinkage of live hogs in transport is incorporated into the model. This factor affects both the requirement of equivalency among total quantities and transport costs

TABLE XI

ACTUAL 1979 POPULATION DISTRIBUTION, ADJUSTED PER CAPITA PORK CONSUMPTION, AND REGIONAL DISTRIBUTION OF BASE-YEAR PORK CONSUMPTION

Region	Population	Proportion of Total	Per Capita Pork Consumption	Regional Consumption	Proportion of Total
	(thousand)	(percent)	(lbs./yr.)	(mil. lbs.)	(percent)
1-PA	11,731	5.36	59.67	685.9809	4.49
2-NC	10,803	4.94	82.13	869.5377	5.69
3-GA	8,049	3.68	82.13	647.8671	4.24
4-FL	8,860	4.05	82.13	713.1447	4.67
5-AL	6,198	2.83	103.19	626.7971	4.10
6-TN	7,907	3.61	103.19	799.6266	5.23
7-IN	16,131	7.37	66.69	1054.2480	6.91
8-MI	9,207	4.21	66.69	601.7275	3.94
9-WI	4,720	2.16	66.69	308.4775	2.02
10-IL	11,229	5.13	66.69	733.8762	4.81
11-AR	2,180	1.00	77.22	164.9709	1.08
12-MO	4,867	2.22	77.69	370.5520	2.43
13-IA	2,902	1.33	77.69	220.9456	1.45
14-MN	4,060	1.86	77.69	309.1106	2.02
15-ND	657	.30	77.69	50.0211	.33
16-NE	2,263	1.03	77.69	172.2949	1.13
17-KS	2,369	1.08	77.69	180.3653	1.18
18-OK	2,892	1.32	77.22	218.8514	1.43
19-TX	13,380	6.13	77.22	1012.5280	6.63
20-CO	2,772	1.27	68.86	184.3500	1.21
21-MT	2,141	.98	68.86	142.3857	.93
22-UT	2,069	.95	68.86	137.5974	.90
23-AZ	3,691	1.69	68.86	245.4674	1.61
24-CA	22,694	10.37	61.31	1363.4280	8.94
25-OR	6,453	2.95	61.31	387.6887	2.54
26-LA	4,018	1.84	77.22	304.0609	1.99
27-MD	7,264	3.32	82.13	584.6820	3.82
28-NY	37,271	17.04	59.67	2179.4208	14.28
TOTAL	218,778	100.01[a]		15,270.0040	100.00

[a]Total does not equal 100.00 due to rounding error.



Source: Market Research Corporation of America, 1978.

Figure 12. Regional Demarcation for Market Research Corporation of America Pork Consumption Indexes

for live hogs. The latter of these effects will be addressed in a subsequent section.

Ikerd (1976) provided data relating percent shrinkage to length of haul. Ordinary least-squares regressions are done using several functional forms. The following semi-logarithmic equation is selected:

$$S_{ij} = -1.429437 + 1.004648\ (\ln M_{ij}) \qquad R^2 = .9704 \tag{4.1}$$

where S_{ij} = percent shrinkage from the ith producing region to the jth slaughter region, and

M_{ij} = miles between the ith production region and the jth slaughter region.

The negative intercept of equation 4.1 has no logical meaning since it implies weight gains for short hauls. Henning and Thomas (1962) found that a shrinkage of 1.18 percent of live weight occurred for shipments of hogs over distances of zero to nine miles. This shrinkage is mainly attributable to handling during loading and is thus applied as an artificial minimum to values computed from equation 4.1.

As was previously stated, the equivalency of the total quantity produced, slaughtered, and consumed is required by the model. The introduction of shrinkage makes it necessary for production to exceed slaughter (in absolute units) and affects the computation of the regional distribution of base-year production. Thus, the original production constraints for all regions are adjusted to allow the production of the total quantity of hogs slaughtered plus the total amount of shrinkage. The amount of total shrinkage can be determined only after examining a specific solution since the transhipment model selects those shipments which minimize costs and since the total amount of shrinkage is dependent upon the total length of hauls (and thus, which shipments are in the solution). Stair-step production activities allow for increases in regional production above the base year distribution quantities. Slack activities for original production show the amount by which regional original production falls short of the base year distribution. The total amount of adjustment of the base year distribution needed to allow original production activities to fulfill the requirement of equivalency is determined by comparing the total of all original slack activities to the total of all stair-step production activities in the basic solution. Since the sum of the stair-step production activities in the initial solution exceeds the sum of the original slack activities in solution, original production constraint values are increased. The amount of increase is computed to determining the percent of total production represented by the excess of stair-step production over original slack and multiplying each original constraint by one plus this percentage. Mathematically, this is shown by:

$$\left(1 + \frac{\sum_{i=1}^{l} (SSPA_i - OSA_i)}{\sum_{i=1}^{l} (OPA_i + SSPA_i)}\right) \cdot OPRHS_i = OPRHS_i' \qquad (4.2)$$

where i = production region, $i = 1, \ldots, l$,

$SSPA_i$ = solution level of the stair-step production activities in the ith production region,

OSA_i = solution level of the slack activity for the original production activity in the ith production region,

OPA_i = solution level of the original production activity in the ith production region,

$OPRHS_i$ = the initial original production constraint value for the ith production region, and

$OPRHS_i'$ = the adjusted original production constraint value for the ith production region.

Unique adjustments in constraint values are necessary for specific procedures. The exact adjustments depend upon whether the objective is to 1) select optimal production locations, or 2) require certain levels of production in all regions. Adjusted constraint values for original production activities for all situations are shown in Table XII.

Slaughter Capacities

Any region's capability to slaughter hogs is constrained at a level determined by its total slaughter plant capacity. To the author's knowledge, there are no known current publications which provide this data and thus some method of estimation must be employed.

Slaughter capacities for all regions are computed by multipying each region's highest monthly slaughter in 1979 (U. S. Department of Agriculture, 1980E) by 12. This method yields an estimate of annual slaughter capacity. The reasoning behind the use of 1979 data is that hog slaughter was extremely high in 1979 due to high level of production and liquidation of breeding herds. In addition, logic leads to the conclusion that if a region can actually slaughter a certain amount of hogs in any one peak month, then 12 times this amount is a reasonable estimate of annual slaughter capacity.

As was previously noted, the base quantity of 15.27 billion pounds of pork is distributed according to regional slaughter in 1979 to obtain base year slaughter quantities. The base quantity of slaughter in live weight (23.0577 billion pounds) is greater than the total slaughter for the period upon which the slaughter capacities were based. This discrepancy may be due to some plants not being included in the Livestock Slaughter Annual Summary for 1979, differences in data

TABLE XII

ORIGINAL PRODUCTION CONSTRAINT VALUES FOR THE VARIOUS SOLUTION SITUATIONS

Region	Required Production Slaughter, and Consumption[a]	Required Production and Consumption[a]	Required Consumption (Base year distribution + 1%)[b]
		(mil. lbs., live)	
1-PA	233.0086	232.5038	234.8288
2-NC	1115.7600	1113.3430	1124.4760
3-GA	861.9019	860.0348	868.6353
4-FL	152.6076	152.2700	153.7998
5-AL	465.5527	464.5442	469.1897
6-TN	1043.9450	1041.6840	1052.1010
7-IN	2662.7120	2656.9440	2683.5130
8-MI	343.3040	342.5603	345.9859
9-WI	662.2176	660.7830	667.3909
10-IL	2897.9120	2891.6330	2920.5500
11-AR	227.1620	226.6699	228.9366
12-MO	1767.9360	1764.1070	1781.7470
13-IA	6026.9180	6013.8408	6073.9793
14-MN	1866.7950	1862.7500	1881.3770
15-ND	120.9926	120.7305	121.9378
16-NE	2432.0960	2426.8270	2451.0960
17-KS	836.1867	834.3753	842.7192
18-OK	125.9430	135.6701	126.9268
19-TX	357.4980	356.7235	360.2908
20-CO	163.2971	162.9433	164.5727
21-MT	118.3626	118.1062	118.1062
22-UT	18.7446	18.7040	18.7040
23-AZ	85.1323	84.9479	84.9479
24-CA	86.4523	86.2650	86.2650
25-OR	76.6657	76.5095	76.5095
26-LA	44.4012	44.3050	44.3050
27-MD	114.5452	114.2971	114.2971
28-NY	103.8403	103.6153	102.6153
TOTAL	25,011.8900	24,967.6875	25,200.8036

[a]Used in procedures for objective one.

[b]Used in procedures for all other objectives.

tabulation methods, etc. In order to state slaughter capacities in base year quantities, the capacities are multiplied by the ratio of base year slaughter to actual 1979 slaughter. This ratio is 1.120699:1. Adjusted capacities are shown in Table XIII. All capacities are large enough to accommodate the respective region's base year slaughter.

The capacities shown in Table XIII are used in all solutions for all regions except region 18 (Oklahoma) where one of the objectives is to determine the effect of the closure of the Wilson Foods Corporation plant at Oklahoma City. The capacity of the Wilson Foods Corporation pork slaughter plant at Oklahoma City is estimated to be 252.6 million pounds live weight per year. For objectives where the Wilson Foods Corporation plant at Oklahoma City is assumed closed, the slaughter capacity for region 18 is 120.428 million pounds live weight.

Demand and Supply Functions

As was detailed in Chapter III, the model utilizes log-linear demand functions for pork and stair-step approximations for log-linear supply functions for live hogs. The determination of these functions requires estimates of respective elasticities, quantities, and prices or costs.

The own-price elasticity of demand for pork used in this study is -.413013 (George and King, 1972). It is assumed that this elasticity is constant across all regions.

The average price of pork at the retail level in 1979 was $1.441 per pound (U. S. Department of Agriculture, 1980C). This price is a weighted average of all cuts of pork and is adjusted for edible offal and tallow. Regional price indexes reported by George and King (1972)

TABLE XIII

REGIONAL SLAUGHTER CAPACITIES

Region	Slaughter Capacity
	(mil. lbs., live)
1-PA	952.4016
2-NC	1521.4537
3-GA	769.4650
4-FL	47.8467
5-AL	785.3973
6-TN	1594.7182
7-IN	2357.8933
8-MI	1590.2517
9-WI	638.1237
10-IL	2425.1559
11-AR	72.9721
12-MO	1039.1470
13-IA	7421.3063
14-MN	1539.6781
15-ND	14.0587
16-NE	2280.0659
17-KS	409.8136
18-OK	373.0354
19-TX	485.6823
20-CO	150.6845
21-MT	196.2125
22-UT	38.6730
23-AZ	78.4210
24-CA	475.5322
25-OR	258.9294
26-LA	55.3725
27-MD	137.3423
28-NY	199.1528

are applied to this national average price to solve for regional prices in the four standard regions used in USDA studies.

Equation 3.9 is solved for α by inserting regional consumption quantities (Table XI), regionally adjusted prices (as computed above), and the estimate of the elasticity of demand for pork. These scale factors, shown in Table XIV, implicitly account for all factors affecting demand except own-price. The demand equations relate hundredweights of pork to price per hundredweight.

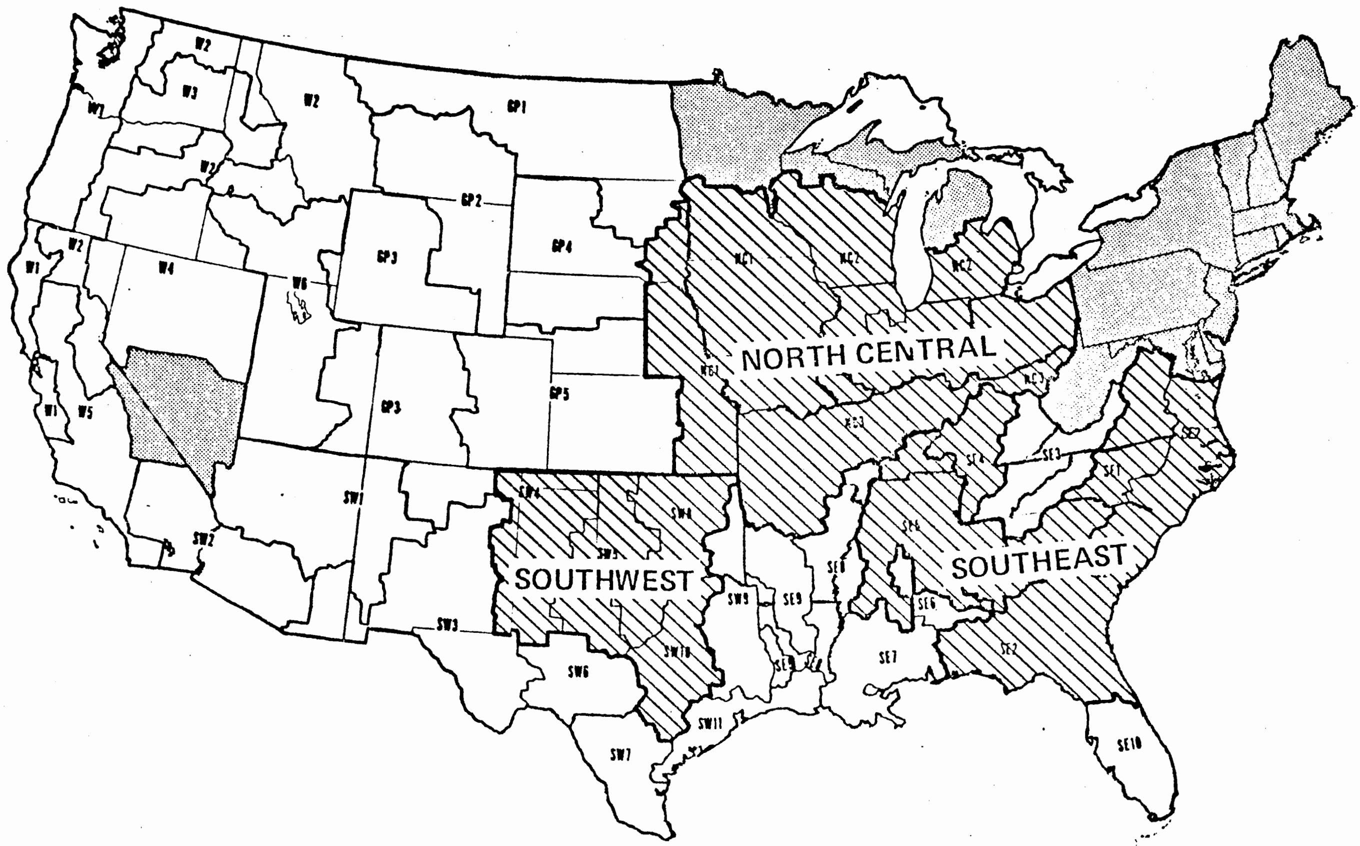
Hog production costs vary with the type of enterprise being considered. Bullock and Beals (1975) found that farrow-to-finish enterprises had substantial cost advantages over the alternative feeder pig-pig finishing system of production. Due to this cost advantage, United States Department of Agriculture estimates of farrow-to-finish production costs are used as objective function values in live production activities. These estimates are shown in Table V for the regions depicted by Figure 13. An assignment of the cost data to the regions of this study appears in Table XV.

There are 20 variable production regions. The regions are denoted by numbers 1 through 20. Two of the variable production regions, 1 and 20, are not included in the areas surveyed by the USDA for cost of production estimates for hogs. Region 1 and 20 represent Pennsylvania and Colorado, respectively. These regions are designated as variable production regions because their 1979 actual production exceeded that of Oklahoma and they are near areas for which cost estimates are available. Due to the relative location of these regions' major areas of production, North Central costs of production are assumed to be representative for both regions.

TABLE XIV

SCALE FACTORS (α) FOR REGIONAL DEMAND FUNCTIONS OF THE FORM $Q = \alpha P^{\beta}$

Region	Scale Factor
	($x 10^9$)
1-PA	5,778,243,000
2-NC	8,365,708,000
3-GA	4,102,590,000
4-FL	5,176,231,000
5-AL	3,787,081,000
6-TN	6,829,161,000
7-IN	14,492,940,000
8-MI	3,728,221,000
9-WI	739,443,700
10-IL	6,029,250,000
11-AR	149,509,700
12-MO	1,152,663,000
13-IA	329,597,900
14-MN	743,140,800
15-ND	9,036,027
16-NE	180,495,800
17-KS	201,651,800
18-OK	296,384,700
19-TX	12,094,390,000
20-CO	219,430,700
21-MT	117,409,300
22-UT	108,076,100
23-AZ	438,916,100
24-CA	27,881,380,000
25-OR	1,327,328,000
26-LA	657,090,200
27-MD	3,200,038,000
28-NY	94,911,740,000



Source: U. S. Department of Agriculture, 1980A.

Figure 13. Regional Demarcation for U. S. Department of Agriculture Estimates of Swine Production Costs

TABLE XV

COSTS OF ORIGINAL PRODUCTION AND STAIR-STEP PRODUCTION INCREASES (A & B) FOR VARIABLE PRODUCTION REGIONS

Region	Original Level	Step A	Step B
		($/cwt.)	
1-PA	53.962	56.350	58.860
2-NC	58.142	60.724	63.420
3-GA	58.142	60.724	63.420
4-FL	58.142	60.724	63.420
5-AL	58.142	60.724	63.420
6-TN	58.142	60.724	63.420
7-IN	53.962	56.350	58.860
8-MI	53.962	56.350	58.860
9-WI	53.962	56.350	58.860
10-IL	53.962	56.350	58.860
11-AR	53.962	56.350	58.860
12-MO	53.962	56.350	58.860
13-IA	53.962	56.350	58.860
14-MN	53.962	56.350	58.860
15-ND	53.962	56.350	58.860
16-NE	53.962	56.350	58.860
17-KS	53.962	56.350	58.860
18-OK	55.529	57.994	60.569
19-TX	55.529	57.994	60.569
20-CO	53.962	56.350	58.860

The method described in Chapter III of approximating supply functions by the use of stair-step activities is used for the variable production regions. Each region's production is allowed to increase by one percent of its base-year production at the base cost. Additional production increases (stair-step production activities) are assigned higher costs by using an elasticity of supply of .45 (Ray and Richardson, 1978), which is assumed to be applicable for all regions. The increased costs are computed for two successive increases in production of two percent each. Costs for each of the stair-step production activities are shown in Table XV. Adjusted stair-step production activity constraint levels are shown in Table XVI.

It is assumed that the production of live hogs in regions 21 through 28 remains constant at levels shown in Table XII under the "Required Consumption" column. This assumption is precipitated by a lack of data concerning production costs in these regions and by the fact that these regions' total production amounts to only 2.60 percent of total national production. Since production in these regions is required at a certain level by equality constraints, the cost associated with the regions' live production activities is irrelevant to the determination of an optimal solution. Consequently, production costs in regions 21-28 are excluded.

Transportation Costs

Data concerning costs of transporting live hogs and pork were obtained by surveying transport companies. These data consist of point-to-point and per mile rates for certain minimum load levels. Any applicable minimums on load levels or rates are considered in the

TABLE XVI

STAIR-STEP PRODUCTION ACTIVITY CONSTRAINT LEVELS

Region	Secondary Production Increases A	B
	(live cwt.)	
1-PA	46,966	47,905
2-NC	224,895	229,393
3-GA	173,727	177,202
4-FL	30,760	31,375
5-AL	93,838	95,715
6-TN	210,420	214,629
7-IN	536,703	547,436
8-MI	69,197	70,581
9-WI	133,478	136,148
10-IL	584,110	595,792
11-AR	45,787	46,703
12-MO	356,349	363,476
13-IA	1,214,796	1,239,092
14-MN	376,276	383,801
15-ND	24,388	24,875
16-NE	490,219	500,023
17-KS	168,544	171,915
18-OK	25,385	25,893
19-TX	72,058	73,499
20-CO	32,915	33,573

data transformation procedures utilized before functions are computed. Mileages for all possible shipments were obtained from the Household Goods Carriers Mileage Guide No. 9 (1972).

Nine livestock shippers that regularly transport live hogs were surveyed. Only three of these companies provided complete per mile rate schedules. These three per mile schedules are used for function computation because many point-to-point rates involve negotiations between the carriers and major shipping or receiving clients. Plots of these data appear in Figure 14.

Regression equations are computed using several functional forms and dummy variables. The dummy variables are included to account for minimum charges imposed by the companies. Each equation expresses cost per hundredweight as a function of miles.

A serious discrepancy is found between the plots of the actual data and the plot of the oridnary least-squares regression equation selected as "best" which also appears in Figure 14. Note that the intercept of the standard regression line (ignoring the minimum cost imposed by dummy variables) is negative while the intercepts of all plots of actual data are greater than or equal to zero. This discrepancy is caused by the divergence of the raw data as distance increases. Due to the negative intercept of the regression, transport costs per hundredweight per mile increase for hauls of 150 miles or more. This makes no economic sense.

In order to derive an equation which had a reasonable semblance to the raw data, a mathematical averaging technique is employed. The minimum charges, intercepts, and slopes of the functions for the three data sets were averaged. The resulting equation is:

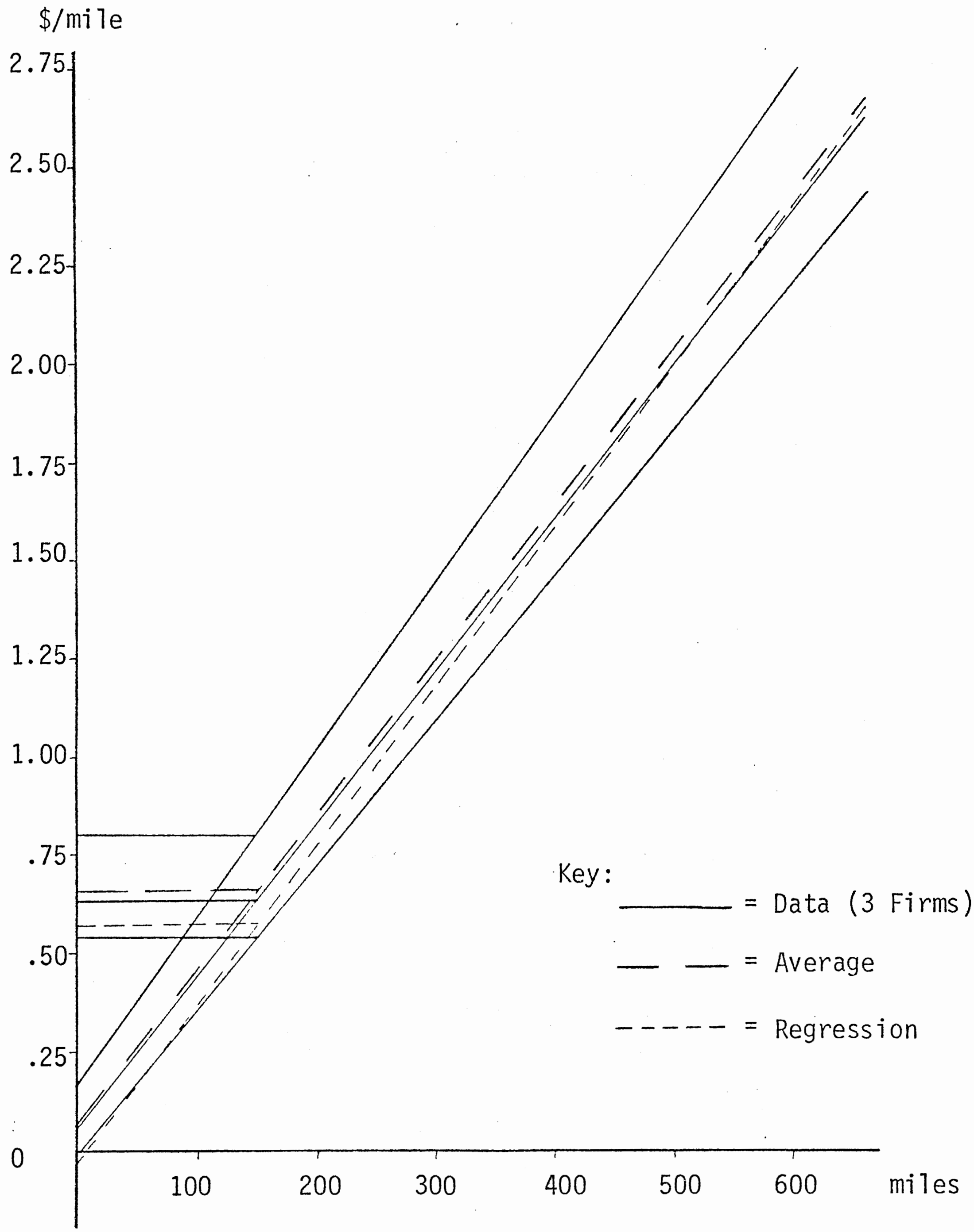


Figure 14. Plots of Data, Regression, and Mathematical Average Functions for Live Transport Costs

$$LT_{ij} = .076829 + .0038897 * M_j \tag{4.3}$$

where LT_{ij} = transport costs per hundredweight from the ith production region to the jth slaughter region and

M_{ij} = miles between the ith production region and the jth slaughter region.

The average of the minimum per mile charges is \$.660284 per hundredweight for hauls of 150 miles or less. This value is imposed as an artificial minimum for equation 4.3. The function is plotted in Figure 14.

As was previously mentioned, transport costs for live hogs are affected by shrinkage because slaughter regions do not actually receive the amount of live hogs upon which transport costs are paid. It is assumed that transport costs are based on liveweight at the point of origin. Thus, an adjustment of transport costs is made.

The live hog transport costs computed by using equation 4.3 are adjusted to determine the effective transport cost per hundredweight for all shipments. Effective transport costs are the costs per hundredweight of live hog received by the slaughter region and are computed as:

$$ELT_{ij} = \frac{LT_{ij}}{1 - S_{ij}} \tag{4.4}$$

where ELT_{ij} = effective live transport cost from the ith production region to the jth slaughter region and

LT_{ij} and S_{ij} are as previously defined.

In other words, transport costs based on farm weight are adjusted to transport costs based on the weight of the hogs as they arrive in slaughter regions. Thus, total transport costs for live hogs are computed by the model as:

$$\sum_{i=1}^{l} \sum_{j=1}^{m} (ELT_{ij} \cdot Q_{ij} (1 - S_{ij})) = TLTC \tag{4.5}$$

where Q_{ij} = the quantity of live hogs shipped from the ith production region to the jth slaughter region,

TLTC = total live transport costs, and

ELT_{ij} and S_{ij} are as previously defined.

Five refrigerated transport carriers provided per mile rates and load levels from which data sets in dollars per hundredweight are constructed. Again, least-squares regressions relating dollars per hundredweight to miles are computed using several functional forms. The linear form was selected because of a comparable R-square and greater significance of parameters. The equation is:

$$MT_{jk} = .838952 + .002316\ M_{jk} \qquad R^2 = .9758 \tag{4.6}$$

where MT_{jk} = transport costs per hundredweight from the jth slaughter region to the kth consumption region and

M_{jk} = miles between the jth slaughter region and the kth consumption region.

The average of the minimum charges used by livestock truckers is \$.9983 per hundredweight. Most firms apply this minimum to hauls of 150 miles or less. Therefore, all hauls of 150 miles or less are assigned a minimum meat transport cost of \$.9983 per hundredweight.

An examination of the data raises questions about the appropriateness of equation 4.6 for shipments to California and Florida. Rates for these shipments appear lower, probably due to the greater probability of backhauls of fresh fruit and vegetables in refrigerated trailers. In order to ascertain the significance of this difference, separate regressions are made for shipment rates to California and Florida, regions 4-FL and 24-CA respectively. The equation selected is:

$$MT_{jk} = .337676 + .000239\ M_{jk} \qquad R^2 = .5581 \tag{4.7}$$

where MT_{jk} = trasnport costs per hundredweight from the jth slaughter region to the kth consumption region, k = 4, 24, and

M_{jk} = miles between the jth slaughter region and the kth consumption region, k = 4, 24.

A statistical test of the differences between the intercept and slope terms of equations 4.6 and 4.7 is made. The following t-values are computed:

Slope: $t_{75,\alpha} = 2.87318$

Intercept: $t_{75,\alpha} = -.402644$

The above values are compared to the values of t:

$t_{60,.01} = 2.660$

$t_{120,.01} = 2.617$

$t_{60,.05} = 2.000$

Based on these comparisons, the hypothesis that the slope terms are equal is rejected and the hypothesis that the intercept terms are equal is not rejected. Since, for long distances, the slope term has a large effect on total transport costs, the equations are concluded to be significantly different. Equation 4.7 is used to compute transport costs for meat shipments to California and Florida.

All of the refrigerated transport companies surveyed imposed a 19 percent fuel surcharge on the total cost of each shipment. Consequently, all final meat transport costs in the model are increased by 19 percent.

Since the surveys of both livestock shippers and refrigerated transport companies were conducted in April, 1981, deflation of computed costs to 1979 levels is required. Detail indexes from the Wholesale Price Index and Producers Price Index (U. S. Department of Labor, 1979 and 1981) are used. Respective price indexes for fuel and trucks are weighted by a three-to-one ratio to arrive at a deflation factor of .75336. Matrices of mileages and effective transportation costs for both shipment sectors appear in Appendix B.

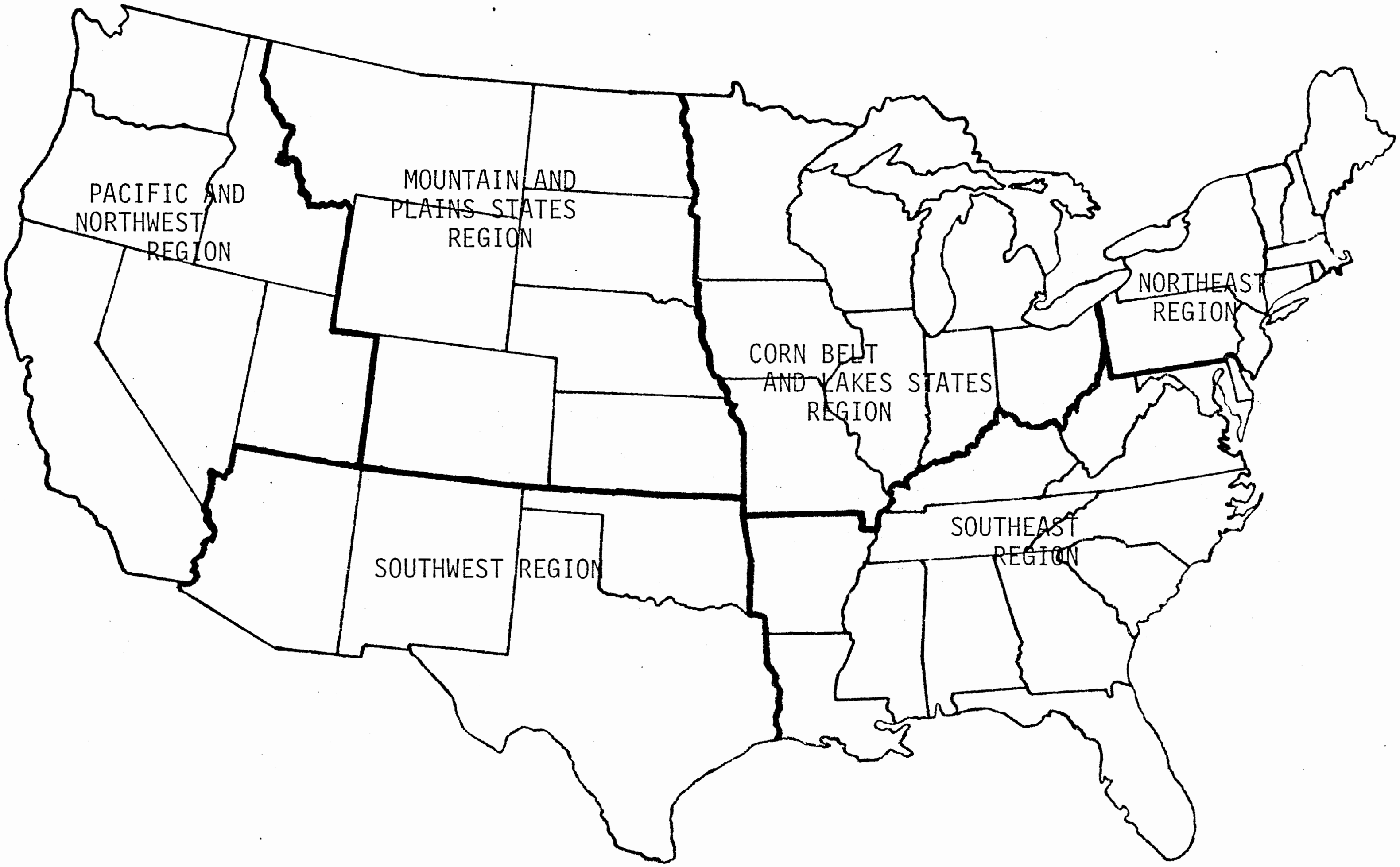
Slaughter Costs

The slaughter costs used in this study are based on a 1974 survey of pork slaughter and processing plants conducted by Food Management, Incorporated (1974) for the U. S. Department of Agriculture. Data from this study were divided into cost components with labor being expressed in hours per head and all other factors in dollars per head. The analysis is based on the six regions shown by Figure 15. The actual computation of regional slaughter costs uses several pieces of additional information. The following paragraphs detail the information and computational procedures.

First, weighted averages of non-labor costs (dollars per head) and labor requirements (hours per head) are computed for each region in the Food Management, Incorporated (FMI) study. The weighting factor is actual slaughter in each plant for the survey period, August, 1974.

Second, non-labor costs are inflated to reflect 1979 price levels. inflation factors are based on U. S. Department of Agriculture data, detail indexes of Producers Price Index (U. S. Department of Labor, 1974 and 1979), and detail labor indexes from Earnings and Employment (U. S. Bureau of Labor Statistics, 1974 and 1979).[1]

[1]U. S. Department of Agriculture inflation indexes were obtained in an interview with Mr. Lawrence A. Deuwer, USDA, Livestock Economics Division, Washington, D.C., on March 25, 1981.



Source: Food Management, Incorporated, 1974.

Figure 15. Regional Demarcation for the U. S. Department of Agriculture Survey of Pork Slaughter and Processing Costs

The inflation factors for all non-labor costs components are shown in Table XVII.

TABLE XVII

NON-LABOR SLAUGHTER COST INFLATION FACTORS FOR 1974 TO 1979

Cost Component	Factor
Procurement	1.437
Supplies	1.525
Fuel	2.137
Other Variable Costs	1.546
Sanitation Labor	1.533
Repair Labor	1.548
Inspection	1.333
Administrative	1.437
Depreciation	1.560
Taxes	1.208
Interest	1.275
Other Fixed Costs	1.477

Third, regional wage rates from the American Meat Institute (1980) are applied to regional weighted average labor requirements to compute the labor component of slaughter costs for all regions. The American Meat Institute (AMI) reported regional average wage rates for union and non-union workers as well as an aggregate wage which weighted the union and non-union wages by the proportion of workers employed under such labor situations in each region. The aggregate wages are used to compute the slaughter labor costs used in all procedures except that for objective four. All wage rates appear in Table XVIII. The regions listed in Table XVIII are depicted by Figure 16.

TABLE XVIII

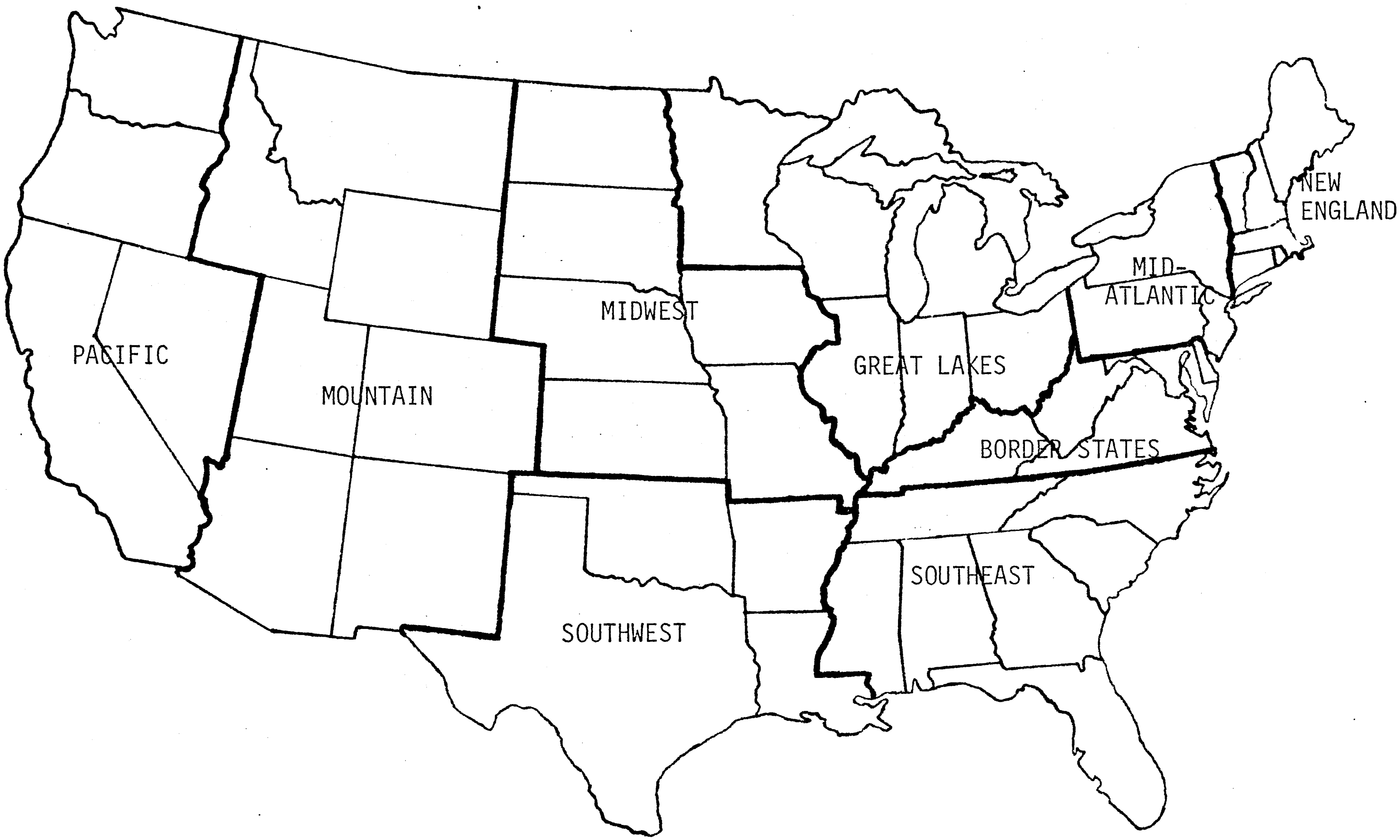
HOURLY WAGE RATES FOR PRODUCTION WORKERS IN THE U. S. MEAT INDUSTRY, 1979

	Wage Rate		
	Aggregate	Unionized	Non-unionized
		(dollars)	
Mid West	7.84	8.22	6.49
Great Lakes	7.45	7.64	4.54
Southwest	5.52	6.30	4.09
Southeast	4.69	5.05	4.29
Mountain	6.88	7.18	4.85
Pacific	8.10	8.10	5.67
Mid-Atlantic	6.14	6.37	5.08

Source: American Meat Institute, 1980.

Finally, the inflated non-labor slaughter costs and labor costs based on 1979 wages are summed for each region in the study to arrive at each region's slaughter costs per head. These are then restated in dollars per hundredweight by dividing by the average slaughter weight in each region during the survey period. Total slaughter costs for all regions and all wage rates are shown in Table XIX.

The slaughter costs for regions 1 and 28 in Table XIX are the result of one additional adjustment. Non-labor costs for the two regions are increased to the point where the ratio of non-labor costs to labor costs



Source: American Meat Institute, 1980.

Figure 16. Regional Demarcation for American Meat Institute Wage Rates

TABLE XIX

TOTAL SLAUGHTER COSTS PER LIVE HUNDREDWEIGHT FOR VARIOUS WAGE RATES, 1979

Region	Total slaughter costs for: Aggregate Wages	Unionized Wages	Non-unionized Wages
		($)	
1-PA	5.2655	5.3324	4.8897
2-NC	4.4695	4.5804	4.3463
3-GA	4.4695	4.5804	4.3463
4-FL	4.4695	4.5804	4.3463
5-AL	4.4695	4.5804	4.3463
6-TN	4.4695	4.5804	4.3463
7-IN	6.1403	6.2221	5.1617
8-MI	6.1403	6.2221	5.1617
9-WI	6.1403	6.2221	5.1617
10-IL	6.1403	6.2221	5.1617
11-AR	4.7252	4.9654	4.2847
12-MO	6.2728	6.4205	5.8287
13-IA	6.2728	6.4205	5.8287
14-MN	6.1403	6.2221	5.1617
15-ND	6.0539	6.1702	5.6405
16-NE	6.0539	6.1702	5.6405
17-KS	6.0539	6.1702	5.6405
18-OK	4.4335	4.8085	3.7460
19-TX	4.4335	4.8085	3.7460
20-CO	5.7599	5.8518	5.1383
21-MT	5.7599	5.8518	5.1383
22-UT	5.5323	5.6248	4.9061
23-AZ	5.0873	5.2316	4.1114
24-CA	5.9086	5.9086	5.1610
25-OR	5.9086	5.9086	5.1610
26-LA	4.7252	4.9654	4.2847
27-MD	4.4695	4.5804	4.3463
28-NY	5.2655	5.3324	4.8897

for regions 1 and 28 is equivalent to the national average ratio. The adjustment is caused by non-labor costs in the USDA survey's Northeast region being extremely low. The cause of these apparent abnormalities, whether it be sampling error, accounting procedures, or other factors, is unknown.

The regional slaughter costs shown in Table XIX were discussed with managers from a regional packer for purposes of verification. After reviewing the data and procedures employed in the computation of these costs, the company representatives indicated that these data accurately portrayed slaughter costs in the pork industry.

Procedures

In Chapter I, the procedures of this study were discussed in general terms. This section addresses the procedures in detail. The procedures for objectives three, five, and six require items of additional data which are largely of an assumed nature and, for the most part, are unrelated to the basic data previously discussed. These data will be detailed when appropriate. Unless otherwise noted, the procedures for all objectives assume that Wilson Foods Corporation's Oklahoma City plant is closed.

The procedure for objective one is designed to solve for optimal shipment patterns assuming that all regions' production and slaughter of live hogs and consumption of pork are at 1979 levels. It utilizes only the transhipment model since 1979 consumption quantities are specified. This goal is accomplished by creating equality constraints for all original production and slaughter activities. Consumption, as has been noted, is required by equality constraints in the transhipment model for all procedures. The constraint levels are shown in Tables XII, X, and XI for production, slaughter, and consumption, respectively. This solution assumes that the Wilson Foods Corporation plant at Oklahoma City is open.

A second goal for objective one is to determine the optimum shipment patterns for 1979 assuming Wilson Foods Corporation's Oklahoma City plant is closed. In order to obtain a solution for this situation, slaughter regions are allowed to vary their actual slaughter subject to their capacity. Therefore, the equality constraints on slaughter activities are omitted from the transhipment model and less-than constraints are introduced. Slaughter capacity constraint levels are shown in Table XIII. A capacity of 1,204,280.6 hundredweights is imposed for region 18 (Oklahoma) to reflect the aforementioned closure of the Wilson plant. Production and consumption are required at the levels shown in Tables XII and XI, respectively.

The procedure for objective two involves the incorporation of both reactive programming and the transhipment model. Reactive programming is used to determine the quantities of pork demanded in all regions that fulfill spatial equilibrium conditions assuming that slaughter is distributed as in 1979 (Table X). The transhipment model is then employed to solve for the least-cost patterns of production, live shipment, slaughter, and meat shipment to fulfill the spatial equilibrium demands. Slaughter quantities determined by the solution to the transhipment model are then utilized as fixed supplies of pork in the reactive program and meat shipments which satisfy spatial equilibrium conditions are verified. Each region is allowed to vary its production and slaughter in this procedure.

Production in all regions is subject to approximated supply functions formed by the use of costs of production found in Table XV and the original and stair-step production activity constraint levels found in Tables XII and XVI, respectively. Regional slaughter is subject to the slaughter capacities shown in Table XIII.

The procedure used to address objective three involves the creation of a new slaughter region. The interest in this objective is based upon the impending entry of a large beef processor into the pork slaughter industry and the possible effects of its entry. It is assumed that this slaughter region consists of only one plant with a capacity of 480 million pounds of live hogs per year (2 million head of 240-pound hogs). The region neither produces nor consumes. It is also assumed that this plant can slaughter hogs for costs that are 20 percent below those of region 13 (Iowa). The source of such savings is assumed unknown, but possible reasons may be lower wage rates and/or higher technical efficiency. The procedure is implemented with the plant located in four cities in or near Iowa. These cities are 1) Omaha, Nebraska; 2) Kirksville, Missouri; 3) Albert Lea, Minnesota; and 4) Davenport, Iowa. The selection of these locations is based on postulation of the probable location of the new slaughter facility. The procedure utilizes both mathematical routines. A new pork supply region is established in the reactive program and a new slaughter region is established in the transhipment model. Mileages and costs for live hog and meat shipments to and from all locations of this slaughter region appear in Appendix B. Regional production, slaughter, and consumption constraints identical to those of the procedure for objective two are used. The component routines are employed in the same manner as for objective two's procedure.

Objective four addresses the effect of changes in pork slaughter and processing wage rates on optimal production, slaughter, and shipment patterns and, consequently, on Oklahoma's expansion potential. The procedure used to investigate this objective involves the recomputation of all regions' slaughter costs based on totally unionized and totally non-unionized wage rates. These wage rates and the slaughter costs associated with them are found in Tables XVIII and XIX, respectively. Both mathematical routines are employed in the same sequence as that described in the discussion of the procedure for objective two. The only changes made in either routine from those used in the procedure for objective two involve the substitution of the recomputed slaughter costs into the transhipment model's objective function.

Objective five is based upon interest in the effect of increased fuel prices on the spatial arrangement of the components of the U. S. swine-pork industry. The procedure for the investigation of this objective utilizes the reactive program to determine spatial equilibrium demands and the transhipment model to determine least-cost production, slaughter, and shipment patterns to satisfy these demands for five separate, ten percent increases in fuel prices. Multiple objective functions are used in the transhipment model with a solution being computed for each one. The use of the reactive program for verification of spatial equilibrium meat shipment patterns is omitted because all other such verifications yield positive results.

The increases in live hog and meat transport costs are based on data from Johnson and Tyng (1980) and Boles (1980). These data indicate that fuel comprised 26.2 percent of total operating costs for refrigerated trucks hauling vegetables and 35.7 percent of costs for non-refrigerated trucks hauling grain. These estimates are assumed to be applicable to meat and livestock shipments. Fuel is proportionally more important for the non-refrigerated truck because of higher labor and investment costs associated with the refrigerated truck.

The above estimates of the proportion of total costs of trucking are combined with the assumed increases in fuel costs to derive the actual increases in transportation costs. Since fuel prices are assumed to increase in ten percent increments, transport costs increase by 2.26 and 3.57 percent per increment for pork and live hogs, respectively.

The procedure for the final objective, number six, concerns the investigation of optimal production, live shipment, slaughter, and meat shipment patterns to fulfill spatial equilibrium demands for 1990 population distributions. Note that the jist of this procedure is to find the effects of changes in the population distribution, not increases in population. Therefore, 1990 population projections (U. S. Bureau of the Census, 1980) are used to determine each region's proportion of projected 1990 population by the formula:

$$\text{Proportion} = \frac{\text{Projected 1990 regional population}}{\text{Projected 1990 national population}} \tag{4.8}$$

These projections are based on 1970-1975 population movements. National population for 1979 is then multiplied by the 1990 regional population proportions from equation 4.8 to obtain the 1990 distribution of base-year population. This redistribution allows the estimation of many 1990 parameters (production, income, slaughter capacity, costs of various marketing activities, etc.) to be avoided and enables questions concerning the effect of recent population shifts to the Sun Belt states to be answered. The 1990 distribution of base-year population appears in Table XX.

The population distribution shown in Table XX is used to compute new scale factors (α in equation 3.9) for 1990 demand functions. These factors appear in Table XXI. Per capita pork consumption for 1990 is assumed to be the same as that for 1979 and the 1978 regional consumption indexes are assumed to still portray differences in regional tastes and preferences for pork. An elasticity of demand of -.413013 is also assumed to still be applicable.

The reactive program is used to determine spatial equilibrium demand quantities based on the 1990 demand functions. These consumption levels are then placed in the transhipment model to solve for least-cost production, slaughter, and shipment patterns. Constraint levels for production and slaughter activities are identical to those used in the procedure for objective two. All costs are assumed to be constant. The reactive program is then resolved to verify that the meat shipment patterns found in the transhipment solution are those associated with fulfillment of spatial equilibrium conditions.

TABLE XX

REGIONAL DISTRIBUTION OF BASE-YEAR POPULATION BASED ON PROJECTIONS OF 1990 REGIONAL POPULATION

Region	1979 Population Distribution	1979 Proportion of National Population	1990 Population Distribution	1990 Proportion of National Population
	(thousands)	(percent)	(thousands)	(percent)
1-PA	11,731	5.36	10,914.39	5.05
2-NC	10,803	4.94	11,361.14	5.25
3-GA	8,049	3.68	8,618.89	3.99
4-FL	8,860	4.05	10,928.71	5.06
5-AL	6,198	2.83	6,049.43	2.80
6-TN	7,907	3.61	7,850.74	3.63
7-IN	16,131	7.37	14,846.45	6.87
8-MI	9,207	4.21	8,786.31	4.07
9-WI	4,720	2.16	4,653.68	2.15
10-IL	11,229	5.13	10,433.47	4.83
11-AR	2,180	1.00	2,219.41	1.03
12-MO	4,867	2.22	4,591.91	2.13
13-IA	2,902	1.33	2,713.60	1.26
14-MN	4,060	1.86	3,883.74	1.80
15-ND	657	.30	624.91	.29
16-NE	2,263	1.03	2,204.19	1.02
17-KS	2,369	1.08	2,187.18	1.01
18-OK	2,892	1.32	2,845.21	1.32
19-TX	13,380	6.12	13,735.42	6.36
20-CO	2,772	1.27	3,052.02	1.41
21-MT	2,141	.98	2,174.64	1.01
22-UT	2,069	.95	2,122.72	.98
23-AZ	2,691	1.69	4,052.95	1.87
24-CA	22,694	10.37	22,481.43	10.41
25-OR	6,453	2.95	6,103.15	2.82
26-LA	4,018	1.84	3,809.43	1.76
27-MD	7,267	3.32	7,344.01	3.40
28-NY	37,271	17.04	35,457.65	16.42
TOTAL	218,778	100.01[a]	216,056.78	100.00

[a]Total does not equal 100.00 due to rounding error.

TABLE XXI

SCALE FACTORS FOR LOG-LINEAR DEMAND FUNCTIONS BASED ON THE 1990 DISTRIBUTION OF BASE-YEAR POPULATION

Region	Scale Factor
	(x 10^9)
1-PA	4,523,436,000
2-NC	10,826,720,000
3-GA	5,546,688,000
4-FL	9,855,865,000
5-AL	4,090,784,000
6-TN	7,689,323,000
7-IN	12,497,300,000
8-MI	3,509,293,000
9-WI	753,258,300
10-IL	5,332,291,000
11-AR	178,869,300
12-MO	1,055,443,000
13-IA	295,335,300
14-MN	703,571,700
15-ND	8,437,712
16-NE	178,519,400
17-KS	175,200,000
18-OK	326,386,300
19-TX	14,763,150,000
20-CO	282,924,600
21-MT	124,526,600
22-UT	117,452,600
23-AZ	562,252,300
24-CA	27,835,070,000
25-OR	1,184,522,000
26-LA	661,622,100
27-MD	3,764,481,000
28-NY	78,577,320,000

CHAPTER V

RESULTS

This chapter is devoted to a presentation of the results of the procedures detailed in Chapter IV. The presentation deals mainly with shadow prices, range values and production and slaughter patterns. Since all solutions represent least-cost production, slaughter and shipment patterns to fulfill spatial equilibrium demands for pork, the cost of pork to society is minimized for each situation. The amount of this cost is not of interest to the study. Expansion potential for Oklahoma's swine-pork industry is of primary interest. Thus, objective function values for solutions are not addressed herein.

Model Accuracy

The model of particular interest to the study depicts the swine-pork industry by assigning activities which approximate supply functions for production regions and capacities for slaughter activities. The cost-minimizing patterns of production, slaughter and shipments that fulfill spatial equilibrium demands for pork are then determined. These spatial equilibrium demands are also determined by the model. Due to the nature of the data which are used, this solution does not exactly depict the production, slaughter or consumption levels of all regions for 1979. Whether these discrepancies are caused by naivety on the part of data and/or procedures or by diseconomies in the industry is difficult to determine.

Solutions to the procedure for first objective serve as a base to which the "variable" production and slaughter model is compared. The status of the Wilson Foods Corporation plant at Oklahoma City is pivotal to this comparison in that different models and data must be used for comparisons depending on whether the plant is open or closed.

Assuming that the Wilson Foods plant at Oklahoma City is open, the variable production and slaughter model is compared with a model in which production, slaughter and consumption are constrained at 1979 levels. Tables XXII, XXIII and XXIV show a comparison of these quantities. Note that the optimal regional production and consumption quantities (Tables XXII and XXIV, respectively) are very similar to those of 1979. The discrepancy of 51.66 million pounds of production between the two models is caused by the fixed distributions of production and slaughter in the equality model. These distributions necessitate the inclusion of live hog shipments in the equality model's solution which involve a greater amount of total shrinkage than do live hog shipments in the solution for the variable production model. The distribution of regional slaughter quantities in the "variable" model's optimal solution is not nearly as similar to the actual 1979 distribution as are the optimal solution distributions of production or consumption. This inaccuracy is likely due to data error. In addition, the fact that many slaughter regions were near their slaughter capacity in 1979 caused slaughter in regions 1-PA, 8-MI, 24-CA, and 25-OR to decrease dramatically as the result of relatively small increases in the quantity slaughtered in other regions. Optimal shipment patterns for these solutions appear in Appendix C.

TABLE XXII

1979 ACTUAL PRODUCTION AND LEAST-COST PRODUCTION, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT OPEN

Region	Least-Cost Production	1979 Production	Difference	Deviation
	(mil. lbs.)	(mil. lbs.)	(mil. lbs.)	(percent)
1-PA	244.32	233.86	10.46	4.47
2-NC	1124.48	1115.76	8.72	.78
3-GA	778.54	861.90	-83.36	-9.67
4-FL	48.41	152.61	-104.20	-6.83
5-AL	469.19	465.55	3.64	.78
6-TN	876.28	1043.30	-167.02	-16.01
7-IN	2683.51	2662.71	20.80	.78
8-MI	352.91	343.30	9.61	2.80
9-WI	667.39	662.22	5.17	.78
10-IL	2920.55	2897.91	22.64	.78
11-AR	228.94	227.16	1.78	.78
12-MO	1781.75	1767.96	13.79	.78
13-IA	6165.46	6026.92	168.54	2.80
14-MN	1881.38	1866.80	14.58	.78
15-ND	106.81	120.99	-14.18	-11.72
16-NE	2451.10	2432.10	19.00	.78
17-KS	842.72	836.19	6.53	.78
18-OK	126.93	124.94	1.99	1.59
19-TX	367.50	257.50	10.00	2.80
20-CO	164.57	163.30	1.27	.78
21-MT	118.11	118.36	-.25	-.21
22-UT	18.70	18.74	-.04	-.21
23-AZ	84.95	85.13	-.18	-.21
24-CA	86.27	86.45	-.18	-.21
25-OR	76.51	76.68	-.17	-.22
26-LA	44.31	44.40	-.09	-.20
27-MD	114.30	114.55	-.25	-.22
28-NY	103.62	103.84	-.22	-.21
Total	24,959.47	25,011.13	-1.66	-.21

TABLE XXIII

1979 ACTUAL SLAUGHTER, LEAST COST SLAUGHTER, AND STATUS OF REGIONS WITH RESPECT TO SLAUGHTER CAPACITY, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLAN OPEN

Region	Least-Cost Slaughter	1979 Slaughter	Difference	Deviation	Least-Cost Slaughter at Capacity
	(mil. lbs. live)	(mil. lbs. live)	(mil. lbs. live)	(percent)	
1-PA	241.47	845.31	-603.84	-71.43	
2-NC	1355.56	1409.60	-54.04	-3.83	
3-GA	769.47	649.95	119.52	18.39	X
4-FL	47.85	33.61	14.24	42.37	X
5-AL	785.40	702.32	83.08	11.83	X
6-TN	1594.72	1408.20	186.52	13.25	X
7-IN	2357.78	2103.02	254.87	12.12	X
8-MI	384.64	1338.58	-953.94	-71.27	
9-WI	638.12	589.65	48.47	8.22	X
10-IL	2425.16	2077.95	347.21	16.71	X
11-AR	72.97	64.37	8.60	13.36	X
12-MO	1039.15	866.53	172.62	19.92	X
13-IA	6844.64	6445.42	399.22	6.19	
14-MN	1539.68	1448.66	91.02	6.28	X
15-ND	14.06	7.55	6.51	86.23	X
16-NE	2280.07	2147.61	132.46	6.17	X
17-KS	409.81	388.40	21.41	5.51	X
18-OK	373.04	306.35	66.69	21.77	X
19-TX	485.68	399.12	86.56	21.69	X
20-CO	150.68	128.85	21.83	16.94	X
21-MT	196.21	150.54	45.67	30.33	X
22-UT	38.67	34.00	4.67	13.74	X
23-AZ	78.42	66.88	11.54	17.25	X
24-CA	90.58	450.18	-359.60	-79.79	
25-OR	75.62	200.06	-124.44	-62.20	
26-LA	55.37	51.33	4.04	7.87	X
27-MD	137.34	110.56	26.78	24.22	X
28-NY	102.41	160.10	-57.69	-36.03	
Total	24,584.68	24,584.70	-.02[1]		

[1]Discrepancy due to rounding error.

TABLE XXIV

1979 ACTUAL CONSUMPTION AND SPATIAL EQUILIBRIUM CONSUMPTION

Region	Spatial Equilibrium Consumption	1979 Consumption	Difference	Deviation
	(mil. lbs. carcass)	(mil. lbs. carcass)	(mil. lbs. carcass)	(percent)
1-PA	721.46	685.98	35.48	5.17
2-NC	841.98	869.54	-27.56	-3.17
3-GA	626.76	647.87	-21.11	-3.26
4-FL	689.50	713.14	-23.64	-3.31
5-AL	606.63	626.80	-20.17	-3.22
6-TN	774.74	799.63	-24.89	-3.11
7-IN	1058.17	1054.25	3.92	.37
8-MI	603.90	601.73	2.17	.36
9-WI	310.08	308.48	1.60	.52
10-IL	737.47	733.88	3.59	.49
11-AR	159.86	164.97	-5.11	-3.10
12-MO	372.46	370.55	1.92	.52
13-IA	222.34	220.95	1.39	.63
14-MN	311.21	309.11	2.10	.68
15-ND	50.23	50.02	.21	.42
16-NE	173.27	172.29	.98	.57
17-KS	181.24	180.37	.87	.49
18-OK	212.12	218.85	-6.72	-3.08
19-TX	979.27	1012.53	-33.26	-3.28
20-CO	187.22	184.35	2.87	1.56
21-MT	144.34	142.39	1.95	1.37
22-UT	139.40	137.60	1.80	1.31
23-AZ	248.17	245.47	2.70	1.10
24-CA	1377.78	1363.43	14.35	1.05
25-OR	391.46	387.69	3.77	.97
26-LA	294.02	304.06	-10.04	-3.30
27-MD	565.13	584.68	-19.55	-3.34
28-NY	2289.78	2179.42	110.36	5.06
Total	15,270.00	15,270.03	-.03[1]	

[1]Discrepancy due to rounding error.

A comparison of the variable production and slaughter model with one in which production and consumption is required at 1979 levels is also made. Both models assume the Wilson Foods plant at Oklahoma City is closed. The representative 1979 model contains equality constraints on production and consumption and less than or equal to constraints on slaughter. Slaughter constraint values are set equal to estimated slaughter capacity. This version of the 1979 model allows slaughter to occur in optimal locations given 1979 distributions of production and consumption. Consumption quantities for this comparison are the same as are shown in Table XXIV. Production and slaughter quantities for these two models are shown in Table XXV and XXVI, respectively. Note that the differences in quantities produced and slaughtered in regions between these models are very small. The differences between the total quantities of live hogs produced in these two models is much smaller than for the two models depicted in Table XXII because slaughter is allowed to take place in optimal locations given the specified distribution of production. The difference of 52 thousand pounds is attributable to a non-optimal production distribution.

Variable Production and Slaughter Solutions for the Base Situation

As was earlier noted, the model which allows production and slaughter to vary among regions is of key interest to this study. This model solves for the patterns of production, live hog shipments, slaughter, and meat shipments which minimize the total cost of fulfilling spatial equilibrium demands. By changing the status of the Oklahoma City plant of Wilson Foods Corporation, the impact of the plant's closure upon Oklahoma's potential for expansion can be ascertained.

TABLE XXV

1979 ACTUAL PRODUCTION AND LEAST COST PRODUCTION, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT CLOSED

Region	Least-Cost Production	Production	Difference	Deviation
	(mil. lbs. lives)	(mil. lbs. live)	(mil. lbs. live)	(percent)
1-PA	244.32	234.81	9.51	4.05
2-NC	1124.48	1113.34	11.14	1.00
3-GA	778.54	860.03	-81.49	-9.48
4-FL	48.41	152.27	-103.86	-68.21
5-AL	469.19	464.54	4.65	1.00
6-TN	876.28	1041.68	-165.40	-15.88
7-IN	2683.51	2656.94	26.56	1.00
8-MI	352.91	342.56	10.35	3.02
9-WI	667.39	660.78	6.61	2.00
10-IL	2920.55	2891.63	28.92	1.00
11-AR	228.94	226.67	2.27	1.00
12-MO	1781.75	1764.11	17.64	1.00
13-IA	6195.46	6013.84	181.62	3.00
14-MN	1881.38	1862.75	18.63	1.00
15-ND	106.81	120.73	-13.92	-11.53
16-NE	2451.10	2426.83	24.28	1.00
17-KS	842.72	834.38	8.34	1.00
18-OK	126.93	125.67	1.26	1.00
19-TX	367.50	356.72	10.78	3.02
20-CO	164.57	162.94	1.63	1.00
21-MT	118.11	118.11	0	0
22-UT	18.70	18.70	0	0
23-AZ	84.95	84.95	0	0
24-CA	86.27	86.27	0	0
25-OR	76.51	76.51	0	0
26-LA	44.31	44.31	0	0
27-MD	114.30	114.30	0	0
28-MY	103.62	103.62	0	0
Total	24,959.47	24,959.99	-.52	

TABLE XXVI

LEAST COST SLAUGHTER FOR VARIABLE PRODUCTION AND 1979 PRODUCTION AND STATUS OF REGIONS WITH RESPECT TO SLAUGHTER CAPACITY, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT CLOSED

Region	Least-Cost Slaughter--Variable Production	Least-Cost Slaughter--1979 Production	Difference	Deviation	Least-Cost Slaughter Under Variable Production At Capacity
	(mil. lbs. live)	(mil. lbs. live)	(mil. lbs. live)	(percent)	
1-PA	241.47	232.07	9.40	4.05	
2-NC	1355.59	1399.96	-44.37	-3.17	
3-GA	769.47	769.47	0		X
4-FL	47.85	47.85	0		X
5-AL	785.40	785.40	0		X
6-TN	1594.72	1594.72	0		X
7-IN	2357.89	2357.89	0		X
8-MI	384.64	353.05	31.59	8.95	
9-WI	638.12	638.12	0		X
10-IL	2425.16	2425.16	0		X
11-AR	72.97	72.97	0		X
12-MO	1039.15	1039.15	0		X
13-IA	7097.25	7082.26	14.99	.21	
14-MN	1539.68	1539.68	0		X
15-ND	14.06	14.06	0		X
16-NE	2280.07	2280.07	0		X
17-KS	409.81	409.81	0		X
18-OK	120.43	120.43	0		X
19-TX	483.68	485.68	0		X
20-CO	150.68	150.68	0		X
21-MT	196.21	196.21	0		X
22-UT	38.67	38.67	0		X
23-AZ	78.42	78.42	0		X
24-CA	90.58	90.58	0		
25-OR	75.62	87.23	-11.61	-13.31	
26-LA	55.37	55.37	0		X
27-MD	137.34	137.34	0		X
28-NY	102.41	102.41	0		
Total	24,584.71	24,584.71	0		

Wilson Foods' Oklahoma City Plant Open

Since the February 15, 1981 announcement that Wilson Foods Corporation would cease hog slaughter activities in Oklahoma City, there has been much discussion concerning what the decision might do to the Oklahoma hog industry. Most debate has dealt with the closure's effect on prices received for Oklahoma-grown hogs. But what might the impact of this decision be upon expansion opportunities? In order to determine this effect, the variable production and slaughter model is solved under circumstances of the Wilson Foods plant being open and closed. The results of the former circumstance follow.

Region 18-OK produces 126.9 million pounds of live hogs in the optimal solution of the variable production and slaughter model with Wilson Foods' Oklahoma City plant open. This is equal to the constraint value for primary production. Slaughter in Oklahoma is in the solution at its capacity, 373.0 million pounds live weight. Live hogs (247.6 million pounds) are imported from Kansas and pork (195.8 million pounds carcass weight) is exported to Texas. Production, slaughter, and shipment patterns for this solution are found in Appendix C.

The shadow price on the primary production constraint in region 18 is $1.90 per hundredweight. This value can be interpreted in two manners.

First, assuming that no additional production capacity can be constructed, the shadow price of $1.90 reveals the degree of expansion potential present for existing operations. The shadow price of $1.90 per hundredweight represents a 3.423 percent increase in production costs. Using the elasticity of supply stated in Chapter IV (.45), this increase is analygous to a 1.54 percent increase in production over the actual 1979 production distribution amount. Production in 1979 is one percent less than the solution (and original production activity constraint) level.

Secondly, by considering the range over which the primary production constraint's shadow price is applicable, the conditions for expansion in the presence of construction of additional production facilities can be determined. Any construction of additional production capacity would shift the region's marginal cost curve to the right and thus increase the quantity of live hogs that the region can supply at a given cost. The shadow price of $1.90 per hundredweight is applicable over the range of 86.98 million pounds to 361.36 million pounds. If production costs in additional production facilities do not exceed production costs in existing facilities by more than $1.90 per hundredweight, Oklahoma can expand its hog production to the upper limit of the range (361.4 million pounds) assuming that all other regions' cost structures remain constant. This figure represents a 188 percent increase in Oklahoma's production over 1979 levels.

Wilson Foods' Oklahoma City Plant Closed

The decision to cease hog slaughter activities at the Wilson Foods plant in Oklahoma City has been made. Future expansion of hog production in Oklahoma must occur in the face of this decision's impact. Thus, the solution concerning variable production and slaughter with Wilson Foods' Oklahoma City plant closed must be compared to the previously described solution and then be used as the basis for all additional comparisons.

Optimal production, slaughter, and shipment patterns for the variable production and slaughter model with Wilson Foods' Oklahoma City plant closed are shown in Appendix C. In this solution, Oklahoma imports pork from Kansas and exports hogs to Texas. This occurrence is caused by the slaughter capacity in Oklahoma being fully utilized. Only Oklahoma-produced hogs are slaughtered in the state.

Oklahoma produces 126.9 million pounds of live hogs which corresponds with the original production constraint for Oklahoma. There are no stair-step production activities in the basis. The shadow price on the original production constraint is \$.89 per hundredweight. This value is applicable over the range of 121.8 to 249.9 million pounds.

The shadow price of \$.89 is analygous with a 1.596 percent increase in costs. Again, using an elasticity of supply of .45, the increased cost of 1.596 percent is commensurate with a .718 percent increase in production in Oklahoma in the absence of a shift in the region's supply function. The static supply function precludes the addition of more production capacity and its corresponding effect on regional cost structure.

If the capacity of hog production facilities in Oklahoma increases and production costs in these additional facilities exceed original production costs by no more than \$.89 per hundredweight, Oklahoma can produce as much as 249.9 million pounds of live hogs. This represents an increase of 98.85 percent over the actual 1979 base production and would allow Oklahoma to export more hogs to Texas, thus forcing Kansas out of the Texas market.

By comparing the possible magnitude of expansion for each status of the Wilson Foods plant, the effect of the plant's closing can be seen. Static cost structure expansion potential decreases by 53 percent with the closing of the Wilson Foods plant. Expansion potential for increasing production capabilities decreases by 47 percent. The amount by which costs may increase for expansion from a shifting supply curve decreases by $1.01 ($1.90 - $.89). Thus, the closure of the Oklahoma City plant by Wilson Foods appears to have a negative effect on live hog production expansion potential in Oklahoma. However, note that even in the face of greatly decreased slaughter capacity in Oklahoma, the opportunity to increase hog production in Oklahoma by almost 99 percent still exists. Furthermore, this is not an absolute limit to Oklahoma production.

There exists a degree of expansion potential beyond the production level of 249.9 million pounds in the solution in which the Wilson Foods plant is closed. However, any further expansion will occur only if production costs for the additional quantities are less than the costs specified in the model. The upper shadow price on the solution in which Oklahoma's original production activity is in the basis at 249.9 million pounds is $.18 per hundredweight. The shadow price is applicable for any solution level up to 257.4 million pounds. Thus, if production costs in additional production facilities in Oklahoma are $.18 per hundredweight less than the specified original costs ($55.35 vs. $55.53), production can be expanded by an additional 7.5 million pounds or 5.97 percent of 1979 production. This increase replaces a portion of Texas' production in the original solution.

Assume that production costs in all hog production enterprises in Oklahoma have decreased by $.18 per hundredweight and Oklahoma has increased its production to 257.4 million pounds, thus replacing a portion of Texas' production. The upper shadow price on the primary production activity in Oklahoma at this solution level is $.14 per hundredweight and is valid for the range of 257.4 to 269.6 million pounds. Therefore, Oklahoma's production of live hogs can increase by another 12.2 million pounds (9.68 percent of 1979 production) if production costs in additional production units are $55.21 per hundredweight or less.

The shadow prices, costs, and production levels for all of these situations are shown in Table XXVII. For models in which the production constraint is the limiting factor, the shadow prices indicate the maximum amount by which costs may increase for the expansion to occur. For those models in which costs are the limiting factor, the shadow prices are the minimum amount by which costs must decrease for the expansion to occur. Table XXVIII shows the maximum production cost levels necessary for expansion potential to be realized assuming the Wilson Foods slaughter facility at Oklahoma City is closed.

Estimates of production costs for three sizes of farrow-to-finish enterprises for the southwestern United States appear in Table XXIX. These data indicate that the first two increments of hog production expansion in Oklahoma can be realized if such expansion occurs in production units with an annual output of 650 head or more. The final increase of 11.8 million pounds is achievable only if the production units with an annual output of 1600 head or more are added.

Variable Production and Slaughter Solutions for Changes in Exogenous Factors

Solutions for the variable production and slaughter model under differing exogenous conditions provide information concerning the impacts of several possible developments. Changes in Oklahoma's expansion potential for production and slaughter are of foremost interest to this study. Several other effects are discussed in following sections.

TABLE XXVII

PRODUCTION COSTS, SOLUTION LEVELS, LIMITING FACTORS, SHADOW PRICES, AND EXPANSION LIMITS FOR HOG PRODUCTION IN OKLAHOMA

Wilson's Status	Production Cost	Solution Level	Limiting Factor	Shadow Price	Upper Limit to Range
	($/cwt.)	(mil. lbs.)		($/cwt.)	(mil. lbs.)
Open	55.53	126.9	Production Constraint	1.90	361.4
Closed	55.53	126.9	Production Constraint	.89	249.9
Closed	55.53	249.9	Cost	.18	257.4
Closed	55.35	257.4	Cost	.14	269.6

Effects of Changes in Exogenous Factors on Oklahoma's Expansion Potential For Live Production

The main point of interest in adapting the model to different situations is to ascertain whether the potential for expansion in

TABLE XXVIII

MAXIMUM PRODUCTION COSTS TO ALLOW GIVEN EXPANSIONS OF LIVE HOG PRODUCTION IN OKLAHOMA AND POTENTIAL MARKETS FOR THE PRODUCTION INCREASES

Expansion			Increase over 1979	Maximum Production	Potential
From	To	Increment	Production	Costs	Market
(mil. lbs)	(mil. lbs.)	(mil. lbs.)	(percent)	($/cwt.)	(Region)
126.9	249.9	123.0	98.85	56.42	19-TX
249.9	257.4	7.5	104.82	55.35	19-TX
257.4	269.2	11.8	114.50	55.21	26-LA

TABLE XXIX

PRODUCTION COSTS FOR LIVE HOGS, SOUTHWESTERN UNITED STATES, FARROW-TO-FINISH ENTERPRISES, BY SIZE, 1979

Annual Production	Production Costs
(head)	($/cwt.)
300	64.11
650	55.30
1600	53.96

Source: U. S. Department of Agriculture, 1981A.

Oklahoma's swine production industry increases or decreases. This effect can be determined by comparing the original production constraints' shadow prices and range values in solutions for all varying exogenous conditions to those found for the base situation. These values, and the exogenous conditions, appear in Table XXX.

TABLE XXX

PRIMARY PRODUCTION CONSTRAINT SHADOW PRICES AND UPPER RANGE LIMITS FOR VARIOUS EXOGENOUS CONDITIONS

Exogenous Condition	Primary Production Constraint Shadow Price	Upper Limit to Shadow Price
	($/cwt.)	(mil. lbs.)
New Packer at:		
Omaha, NE	.8864	249.9
Kirksville, MO	.2890	249.9
Albert Lea, MN	.8864	249.9
Davenport, IA	.3174	249.9
Wage Rates for:		
Unionized labor force	.8864	249.9
Non-unionized labor force	.5574	249.9
Fuel Price Increase of:		
10 percent	.8864	NA[1]
20 percent	.8830	NA
30 percent	.8814	NA
40 percent	.8795	NA
50 percent	.8777	249.9
1990 Population Distributions	.8864	249.9

[1]Range values were computed for only the 50 percent fuel price increase.

The upper range limit for the first possible increase in hog production in Oklahoma is 249.9 million pounds for all changes in exogenous conditions. This quantity is identical to that found in the base solution and represents a 124.3 million pound (98.85 percent) increase over the 1979 level of production. Shadow prices, however, differ from that of the base solution for situations where a new packer locates at either Kirksville, Missouri, or Davenport, Iowa, non-union labor rates are in effect in all regions, or fuel prices increase. The smaller shadow prices for these situations denote a slight decrease in the potential for expansion in existing facilities. They do not, however, denote an absolute decrease in non-static cost structure expansion potential. The smaller shadow prices only denote a smaller amount by which production costs in additional enterprises may exceed those in existing enterprises for the full amount of potential to be realized. Thus, expansion under these conditions is less likely than under the conditions of the base situation. If the expansion did occur in any of the situations, it would allow Oklahoma to replace Kansas as a supplier of live hogs to Texas. There are no cases in which the allowance for increased production costs is made greater by a change in an exogenous factor.

Impacts Upon the Expansion Potential for Oklahoma's Slaughter Industry

Though not an objective of the study, information in the solutions for the various procedures provide an idea of the expansion potential for Oklahoma's slaughter industry. Slaughter expansion is more difficult to accomplish than is production expansion in that it will most likely occur only in economically feasible sized units and involve larger capital investment.

The shadow price associated with the slaughter capacity constraint for Oklahoma is the amount by which the objective function would decrease if one more unit of slaughter capacity was available. The objective function, in this case, represents the total cost of pork as it arrives in consumption regions in carcass form. Thus, the slaughter capacity shadow price is the value of an additional unit of slaughter capacity to society. If 1) this value represents a return on investment greater than the next-best alternative return for the given investment and, 2) the return applies to a range which corresponds to at least one economically feasible slaughter plant or expansion of an existing slaughter plant, then the investment is beneficial to society. The solutions for the procedures of this study provide enough information to answer the first of these questions. However, there exist, to the author's knowledge, no recent studies that define the size of an economically feasible hog slaughter plant. Consequently, the second question remains unanswered.

Table XXXI shows the shadow prices and respective upper range limits of these shadow prices for the slaughter capacity constraint for Oklahoma in all solutions. Note that the first entry in Table XXXI is for Wilson Foods' Oklahoma City plant being open. The constraint value for this situation was 373.0 million pounds live weight as opposed to 120.4 million pounds live weight for other solutions.

Several conclusions can be drawn from the information in Table XXXI. The closing of the Wilson Foods' plant at Oklahoma City increased the value of an additional unit of slaughter capacity in Oklahoma. This

TABLE XXXI

SHADOW PRICES AND UPPER RANGE LIMITS FOR SLAUGHTER CAPACITY IN OKLAHOMA

Situation	Primary Production Constraint Shadow Price	Upper Limit to Shadow Price
	($/cwt.)	(mil. lbs.)
Original with Wilson:		
Open	2.2980	412.5
Closed	3.4057	125.4
New Packer at:		
Omaha, NE	3.4057	125.0
Kirksville, MO	3.3911	125.4
Albert Lea, MN	3.4057	125.4
Davenport, IA	3.3918	125.4
Wage Rates for:		
Unionized Slaughter Forces	3.1784	125.4
Non-Unionized Slaughter Forces	3.6411	125.4
Fuel Price Increase of:		
10 percent	3.4057	NA[1]
20 percent	2.4056	NA
30 percent	3.4050	NA
40 percent	3.4043	NA
50 percent	3.4036	125.4
1990 Population Distribution	3.4057	125.4

[1]Range values were computed for only the 50 percent fuel price increase.

result is very logical. The entry of a new, very efficient packer in the upper Midwest appears to have little effect on the value of additional slaughter capacity in Oklahoma. Unionized wage rates decrease an additional unit's value while non-unionized wages increase its value. The effects of these changes in wage rates are nearly equal in magnitude. Finally, neither fuel price increases nor 1990 population distributions have great impacts upon the value of additional slaughter capacity in Oklahoma. All of these conclusions assume that Oklahoma's slaughter costs remain constant.

The entry of a large, very efficient plant into the pork slaughter industry is included as a situation which warrants investigation because it is known that such entry is planned by a company. Information concerning the size of this plant and the investment involved in its construction are the only data available which can be used to determine the feasibility of building new slaughter facilities in Oklahoma.

The new plant is estimated to have a capacity of 2 million head per year. The investment for the new plant is estimated to be $100 million. Based on these data, it is assumed that the initial capital investment necessary for hog slaughtering facilities is approximately $50 per head of annual capacity. It is also assumed that the potential return of such an investment is equivalent to the value of an additional unit for slaughter capacity.

If the average slaughter weight of hogs killed in a new or expanded plant in Oklahoma is 240 pounds, the value of slaughter capacity per head is $8.17. This value represents a 16.35 percent return on the necessary investment assuming that the prospective packer can capture the entire amount of social benefit. If the next-best alternative return for this investment is less than 16.35 percent, then the opportunity for slaughter capacity to increase in Oklahoma is good. This conclusion is valid only if such expansion can be made in a unit which can slaughter at costs equal to or less than the regional slaughter cost used in this study. The computed return is valid for a plant capable of slaughtering up to five million pounds (20,833 head of 240 pound hogs) per year.

If a new packer was to build a new plant or a local packer was to expand an existing plant in Oklahoma, their slaughter costs would likely be below the level used in the base solution. This is due to their being able to pay non-union wages. Base slaughter costs utilize regional aggregate wages which are influenced strongly by Wilson Foods' being subject to the Master Contract for labor. This agreement involves higher wages and fringe benefits than are received by non-union employees in Oklahoma. Given that slaughter expansion in Oklahoma involves per unit costs commensurate with non-union labor rates while other regions' slaughter costs remain constant, the shadow price for the slaughter capacity constraint increases to $4.09 per hundredweight. This value represents a 19.65 percent return per head on the necessary investment. Thus, under the condition of non-union wages in Oklahoma and aggregate wages elsewhere, the possibility of slaughter expansion in Oklahoma looks even more promising than before.

Other Effects of Exogenous Factor Changes

The exogenous factor changes previously described influence portions of the base solution other than Oklahoma. Changes in quantities of hogs produced and slaughtered in regions and involved in interregional shipment patterns occur in the solutions for several of the differing exogenous circumstances.

The entry of a new hog slaughter plant has different effects on regional slaughter distributions and shipment patterns depending upon the plant's location. Table XXXII shows the slaughter regions whose activity levels decrease upon the entry of the new plant and the quantity by which slaughter in these regions decreases. Region 13-IA (Iowa) appears as a displaced region for all of the possible plant locations. Regions 8-MI (Michigan) and 24-CA (California) appear as displaced slaughter regions for three of the four locations. Consumption regions supplied by the new plant are also shown in Table XXXII. Note that the new plant does not ship pork to Texas (Oklahoma's potential market) regardless of location. In addition, the northern- and eastern-most locations (Albert Lea and Davenport) ship to eastern consumption regions while the southern- and western-most locations (Kirksville and Omaha) ship to the south and west. Optimal shipment patterns for these solutions appear in Appendix C.

Solutions for models whose slaughter costs differ from the base model's because of differing wage rates are compared to the solution for the base model. It is concluded that the regional distribution of hog slaughter is highly insensitive to such changes because only 2.0 and .06 percent of total slaughter is reallocated as a result of lower and higher wage rates, respectively. Table XXXIII shows these reallocations of slaughter quantities. The optimal shipment patterns for these solutions appear in Appendix C.

Insensitivity is also the major finding of the solution concerning increasing fuel prices. The shipment patterns for live hog transport

TABLE XXXII

CONSUMPTION REGIONS SUPPLIED AND SLAUGHTER REGIONS REPLACED BY A NEW SLAUGHTER PLANT AT VARIOUS LOCATIONS

New Plant Location	Consumption Region(s) Supplied	Slaughter Region Replaced	Amount Replaced
			(mil.lbs.live)
Omaha, NE	16-NE	13-IA	480.00
	20-CO		
	23-AZ		
Kirksville, MO	4-FL	13-IA	455.00
		8-MI	15.04
		24-CA	5.22
		1-PA	4.74
Albert Lea, MN	8-MI	13-IA	450.56
	28-NY	8-MI	20.81
		24-CA	5.32
		22-UT	3.31
Davenport, IA	8-MI	13-IA	438.83
	28-NY	8-MI	35.85
		24-CA	5.32

TABLE XXXIII

CHANGES IN SLAUGHTER DISTRIBUTION FOR UNIONIZED AND NON-UNIONIZED WAGE RATES IN THE SLAUGHTER SECTOR

Wage Rate	Increase		Decrease	
	Region	Amount	Region	Amount
		(mil. lbs.)		(mil. lbs.)
Unionized	2-NC	14.91	8-MI	15.04
	13-IA	.13		
Non-Unionized	8-MI	500.41	2-NC	244.23
			13-IA	231.80
			27-MD	24.38

under fuel price increases of 10 to 40 percent are identical. Only four shipments change for fuel price increases of 50 percent with the outgoing shipment, Arizona to California, having a shadow price of \$.00045. In the case of meat transport, only four shipments change in each solution (as compared to the base solution) for the first four 10 percent increases. In all of these cases, the outgoing shipments are either found to be alternates to shipments in the solution or have shadow prices of \$.0001. The meat shipment pattern for fuel price increases of 50 percent involves eight shipments that differ from those in the base solution. The three shipments that leave the solution again have shadow prices of \$.0001 or are shown as alternate shipments for the optimal solution. No shipments involving Oklahoma are included in the above changes. The optimal shipment patterns for all of these solutions (and thus the shipments which differ between them) appear in Appendix C.

Table XXXIV shows the shadow prices of the highest effective production constraints (either original or stair-step) for variable production regions in solution for each postulated increase in fuel prices. Note that as fuel prices increase, the shadow prices of production constraints for regions near population centers increase while those of regions more distant from population centers decrease. Also note that, among the regions whose shadow prices decrease over the range of the fuel price increases, the decrease for Oklahoma (18-OK) is the smallest. This denotes that, for a 50 percent increase in fuel prices, Oklahoma's relative position with respect to expansion potential for live hog production improves.

The solution to the model that satisfies spatial equilibrium demand quantities based on 1990 population distributions contains only

TABLE XXXIV

SHADOW PRICES OF THE HIGHEST PRODUCTION CONSTRAINT EFFECTIVE IN VARIABLE PRODUCTION REGIONS AT VARIOUS LEVELS OF FUEL PRICE INCREASES

Region	Fuel Price Increase						Net Change
	0%	10%	20%	30%	40%	50%	
			($/cwt.)				
1-PA	.61	.62	.63	.65	.66	.67	+.06
2-NC	1.78	1.82	1.87	1.91	1.95	2.00	+.22
3-GA[1]							
4-FL[1]							
5-AL	.67	.68	.70	.72	.74	.76	+.09
6-TN[1]							
7-IN	2.32	2.31	2.29	2.28	2.27	2.25	+.07
8-MI	1.86	1.86	1.86	1.86	1.85	1.85	-.07
9-WI	1.84	1.82	1.79	1.77	1.74	1.71	-.13
10-IL	1.74	1.72	1.70	1.68	1.65	1.63	-.11
11-AR	2.25	2.24	2.23	2.22	2.21	2.20	-.05
12-MO	1.42	1.39	1.36	1.32	1.29	1.26	-.16
13-IA	.91	.89	.87	.85	.82	.80	-.11
14-MN	1.38	1.35	1.32	1.28	1.25	1.22	-.16
15-ND[1]							
16-NE	1.99	1.97	1.95	1.93	1.91	1.89	-.10
17-KS	1.34	1.31	1.28	1.24	1.21	1.17	-.17
18-OK	.89	.88	.88	.88	.88	.88	-.01
19-TX	1.10	1.13	1.15	1.18	1.21	1.24	+.14
20-CO	1.57	1.62	1.66	1.71	1.76	1.81	+.24

[1]Production activities in these regions are not at constrained levels and thus additional production capacity has no value to society. In fact, the costs of producing additional units must be less than original costs for expansion to occur.

minor differences from the solution for the basic situation. Production in Indiana and Ohio (7-IN) increases by 53.7 million pounds while production in Kentucky and Tennessee (6-TN) decreases by 50.44 million pounds. The net increase in national production of 3.2 million pounds may, at first, seem peculiar. But upon closer inspection, it must be concluded that the cost savings from the above reallocation must offset the cost of the additional .0001 percent of live hog shrinkage. Slaughter patterns are also found to be little different from the basic solution as region 2-NC increases slaughter by 126.6 million pounds and regions 8-MI and 13-IA decrease slaughter by 15.0 and 111.6 million pounds, respectively. Least-cost shipment patterns for this solution also appear in Appendix C.

Other Results

The construction of the transhipment model in linear programming format yields information concerning the imputed costs of hogs and pork at various levels of the marketing system. These imputed costs appear as the shadow prices for transfer rows between sectors and for the demand requirement rows. The latter are of major interest.

The shadow prices for demand requirement rows (equality constraints) represent the imputed cost of one pound of carcass pork as it reaches a consumption region. This point in the marketing system may be interpreted as the arrival of pork at a retail grocer or meat market.

The only costs not included in these imputed cost figures involve final processing, packaging, merchandizing, etc. The U. S. Department of Agriculture estimates such costs annually. The retail cost component of the farm-retail price spread for pork in 1979 was estimated to be

35.2 cents per pound. Assuming this cost component is equal for all regions, the total imputed costs of producing, slaughtering, shipping, and retailing pork in each region can be computed by adding 35.2 cents to the shadow price of the region's demand requirement row. The imputed costs appear in Table XXXV.

Table XXXV also shows the spatial equilibrium demand prices for pork in all regions. These prices are computed by the reactive program and appear in its output. Note that the total imputed cost of pork is approximately equal to the spatial equilibrium price for all regions. This occurrence was in no way foreseen or planned. However, it leads to two conclusions. First, the model is accurate in that these findings seem to be logical. Second, the assumption that the swine-pork industry is highly competitive is confirmed because, in the long-run, marginal cost, average cost, and price are equal in a perfectly competitive system.

In the solution for the base model, 51.72 percent of all pork is involved in interregional shipment as compared to just 10.44 percent of live hogs. In addition, regions whose production levels corresponded to production constraints slaughtered as much of their own production as possible while regions whose slaughter capacities are fully utilized produce as much of this slaughter quantity as their production constraints will allow. These occurrences denote the desirability of production-oriented slaughter and reaffirm the conclusions of Stout and Bentley (1962) and Judge and Wallace (1960).

The base model's solution also shows that excess slaughter capacity exists in regions 1-PA, 2-NC, 8-MI, 13-IA, 24-CA, 25-OR, and 28-NY. Recall that three of these regions (8-MI, 13-IA, and 24-CA) were the

TABLE XXXV

IMPUTED WHOLESALE AND RETAIL COSTS AND SPATIAL EQUILIBRIUM PRICES OF PORK FOR THE BASE SITUATION

Region	Demand Requirement Shadow Price	Total Imputed Cost of Retail Pork	Spatial Equilibrium Pork Price
		($/cwt.)	
1-PA	106.92	142.12	143.36
2-NC	106.38	141.58	142.80
3-GA	106.62	141.82	143.08
4-FL	106.90	142.10	143.33
5-AL	106.52	142.72	142.96
6-TN	106.10	144.30	142.55
7-IN	105.80	141.00	142.24
8-MI	106.04	141.24	142.49
9-WI	105.32	140.52	141.75
10-IL	105.41	140.61	141.85
11-AR	106.11	141.31	142.56
12-MO	105.32	140.52	141.75
13-IA	104.95	140.15	141.38
14-MN	104.78	139.98	141.21
15-ND	105.67	140.87	142.10
16-NE	105.19	140.39	141.63
17-KS	105.48	140.68	141.94
18-OK	106.08	141.28	142.53
19-TX	106.78	141.98	143.22
20-CO	106.31	141.51	142.75
21-MT	106.90	142.10	143.32
22-UT	107.16	142.36	143.61
23-AZ	107.88	143.08	144.32
24-CA	108.02	143.22	144.45
25-OR	108.29	143.49	144.72
26-LA	106.84	142.04	143.29
27-MD	106.97	142.17	143.41
28-NY	107.30	142.50	143.73

ones most often replaced by the entry of a new packer in the Corn Belt. All of these regions possess slaughter capacities which far exceed their actual 1979 and optimal production levels. The results once again endorse the conclusion that slaughter should occur near the point of production and confirm a popular belief (Quick and Vogel, 1981) that substantial excess slaughter capacity exists in the Corn Belt area.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary of the Problem and Procedures

The production of hogs in Oklahoma has declined steadily over the past 20 years. The decline has occurred even though hog enterprises have generally been profitable in Oklahoma from both absolute and relative points of view. A considerable degree of interest has been expressed in the possibility of reversing the downward trend in Oklahoma's hog production. The investigation of this possibility is the goal of this study.

Due to the apparent "micro-macro paradoxical" nature of the problem, it is necessary that the major area of study be clearly defined. A macroeconomic (entire industry) approach is used. This choise is based on the reasoning that, since hog enterprises in Oklahoma appear to be profitable to individual producers, regional cost advantages in producing and slaughtering hogs elsewhere must be the cause of Oklahoma's relatively small hog industry.

The procedures of the study employ an integrated model consisting of a reactive program and a linear programming formulation of a transhipment model. Reactive programming is used to determine spatial equilibrium demands for pork and the transhipment model is used to solve for least-cost production, live hog shipment, slaughter, and pork shipment patterns which fulfilled these demands. The reactive program provides strength through its downward sloping demand functions and solutions which reflect spatial equilibrium conditions. The transhipment model provides an avenue by which successive levels of the swine-pork marketing system are investigated and incorporates stair-step approximations of supply functions for live hogs.

Several changes in exogenous factors are postulated and their effects on the base situation are determined. Optimal solution levels, shadow prices, and range values for the production and slaughter sectors are of utmost interest to the study.

The base situation features variable production in 20 regions and fixed production in 8, variable slaughter (subject to capacity) in all 28 regions, and the Wilson Foods Corporation's plant at Oklahoma City being closed. The conditions for and limits to expansion of production and slaughter in Oklahoma are determined from this solution. Comparisons are then made to solutions involving changes in various exogenous conditions to determine whether the expansion potential for production and/or slaughter in Oklahoma is affected by these changes. Also, the effects of the exogenous changes on other regions are examined.

Summary of Results

The optimal solution to the basic situation depicts Oklahoma producing at its constrained level for primary production, 126.9 million pounds of live hogs. This level includes a one percent increase in production over the 1979 level. The shadow price for the production constraint is \$.89 per hundredweight and is valid for up to 249.9 million pounds of production. This shadow price denotes the possibility of a .718 percent increase in production in existing facilities. In addition, it represents the maximum amount by which production costs in new enterprises may exceed costs in existing enterprises for the production of live hogs in Oklahoma to increase to 249.9 million pounds.

By relaxing Oklahoma's primary production constraint, the shadow price on the primary production activity for a production level of 249.9 million pounds is found to be \$.18 per hundredweight. This shadow price is valid for additional production up to 257.4 million pounds. This implies that if production costs in new facilities are \$.18 per hundredweight less than costs in existing facilities, expansion can continue to 257.4 million pounds.

Production costs are decreased by \$.18 (from \$55.53 to \$55.35) per hundredweight for Oklahoma's original production activity and the state's production increases to 257.4 million pounds. A new shadow price of \$.14 per hundredweight is obtained and is found to be valid for up to 269.6 million pounds of pork. The meanings of these values are identical to those for the shadow price of \$.18 and the production level of 257.4 million pounds discussed above.

The expansion potential for hog production when Wilson Foods' Oklahoma City plant is closed is substantially less than when the plant is open. The original production constraint's shadow price for the latter situation is \$1.90 per hundredweight (as compared to \$.89 per hundredweight) and is valid for production increases up to 361.4 million pounds (as compared to 249.9 million pounds).

In the basic situation's solution, Oklahoma exports hogs to Texas because the slaughter activity in Oklahoma is at its capacity level. The first and second possible increases in production described earlier both cause hog shipments to Texas to increase. The third potential increase in production allows Oklahoma to enter the Louisiana market.

As has been noted, Oklahoma's entire slaughter capacity of 120.4 million pounds live weight is utilized in the optimal solution for the basic situation (Wilson Foods' Oklahoma City plant closed). Thus, slaughter cannot increase for subsequent solutions. The shadow price on the slaughter capacity constraint is $3.41 per hundredweight. This shadow price represents the value of each additional unit of slaughter facilities to society for up to five million pounds (approximately 20,000 head) of annual capacity. Assuming that the potential entrant in this sector can capture the entire amount of this value, that slaughter in new facilities costs no more than slaughter in existing facilities and that a unit (one head) of annual slaughter capacity can be built for $50, the entrant can expect a 16.35 percent return on investment.

All 74.8 million pounds of pork produced in Oklahoma in the solution to the basic situation is consumed within the state. In addition, pork is imported from Kansas and Iowa in amounts of 73.3 and 64.0 million pounds, respectively. Domestic pork production plus inshipments fulfill the quantity of pork demanded under spatial equilibrium in Oklahoma, 212.1 million pounds.

The entry of a new packer in various locations in or near Iowa has little effect upon the expansion potential for Oklahoma's hog production or slaughter sectors. The amounts by which production in existing facilities and costs in new production facilities may increase are smaller than for the basic situation when the new plant is located in Davenport, Iowa, or Kirksville, Missouri. Smaller shadow prices ($.31

and $.29 per hundredweight for Davenport and Kirksville, respectively) for Oklahoma's original production constraint in these solutions are the reasons for this conclusion. No other location of the new plant has a substantial effect upon expansion potential in Oklahoma's production or slaughter sector.

Differing wage rates change the value of an additional unit of slaughter capacity in Oklahoma but have no effect upon the production sector. Higher (unionized) wage rates decrease the shadow price on the slaughter capacity constraint to $3.18 per hundredweight. Lower (non-unionized) wage rates increase the shadow price to $3.64 per hundredweight. These shadow prices are analygous to potential returns on investment (under the assumptions stated earlier) of 15.26 and 17.48 percent for higher and lower wages, respectively.

The production, slaughter, and shipment patterns in the basic situation's optimal solution are very insensitive to fuel price increases. The shadow prices for Oklahoma's original production and slaughter capacity constraints decrease by only $.01 and $.002 per hundredweight, respectively, from base solution levels when fuel prices increase by 50 percent. These decreases are negligible, at worst, and are very minor when compared to similar decreases in other regions. No changes occur in live hog or pork shipments to or from Oklahoma over the range of fuel price increases.

Projected 1990 population distributions have no effect whatsoever upon Oklahoma's position in the swine-pork industry. Shipment patterns, production and slaughter quantities, and constraint shadow prices are exactly the same as for the base situation as are shadow price ranges.

If a new packer in Oklahoma can hire labor at or below the regional average aggregate wage rate, the potential return on the initial investment for a new slaughter plant or addition to an existing one increases. The solution for the situation where wage rates in Oklahoma are at non-unionized levels while wages in other regions are at aggregate levels shows a $4.09 per hundredweight value for additional slaughter capacity. This represents a return of 19.65 percent on initial investment assuming the new packer can capture the entire value of each unit of capacity and that the required investment is $50 per head of capacity. The valid range of this shadow price is the same as for the base situation.

The imputed cost of carcass pork at the retail level in all regions is approximately equal to the spatial equilibrium price of pork in all regions. This is determined by comparing the sum of the imputed cost of a pound of carcass pork as it reaches consumption regions and an estimate of the retail price spread per pound of pork to the spatial equilibrium prices computed by the reactive program. The difference between imputed costs and equilibrium retail price is less than .75 percent of retail price for all regions.

The optimal solution to the base situation provides that 51.72 percent of all pork be shipped between regions while only 10.44 percent of live hogs is involved in interregional trade. This result, plus consideration of the production and slaughter constraints that are effective, denotes the desirability of production-oriented slaughter.

Finally, the base situation's solution shows that excess slaughter capacity exists in the Corn Belt, Northeast and Pacific Coast states. This confirms suspicions that, at least in the Corn

Belt, overcapacity of slaughter facilities is a problem. Three of the regions with excess capacity are ones which are most often displaced by the entry of a new packer in the Iowa area.

Conclusions

The primary hypothesis of this study is:

There exist conditions under which Oklahoma can compete favorably with other regions in the production and/or slaughter of swine and under which the industry can expand.

Based on the study's results, the hypothesis cannot be rejected. The conclusions leading to the failure to reject the hypothesis are:

1. There exists, under 1979 conditions, the potential to expand hog production in Oklahoma by 98.85 percent of 1979 production given that a) new production facilities are added, and b) production costs in new facilities exceed 1979 production costs by no more than 1.6 percent.
2. Additional production expansion increments of 5.97 and 9.68 percent of 1979 production can be realized if costs in new production facilities are lower than costs in existing facilities by .32 and .58 percent, respectively.
3. Oklahoma's immediate competitor in both the live hog and pork markets is Kansas. The two states compete for the Texas live hog market and will continue to do so until Oklahoma increases hog production by more than 104.82 percent. Beyond this point, Oklahoma sells hogs to Louisiana. The states compete for the Oklahoma pork market until Oklahoma becomes self-sufficient.

4. The expansion of Oklahoma's slaughter industry appears to be very possible for up to five million pounds of live weight annual capacity (approximately 20,000 head of 240 pound hogs). This conclusion, however, must be qualified in that it assumes that the new (or expanding) packer can a) slaughter hogs at costs equal to or less than 1979 costs, b) capture all (or a substantial portion) of the value of the additional capacity to society, and c) build new facilities or expand existing ones for $50 per head of annual capacity.
5. Oklahoma's expansion potential for hog production in existing and additional production facilities decreases by 53 and 47 percent, respectively, as the result of the closing of the Wilson Foods' Corporation slaughter plant in Oklahoma City. The potential return on investment in additional slaughter capacity increases by 48 percent as the result of this same occurrence.
6. Neither Oklahoma's expansion potentials for hog production and slaughter nor possible returns on investment in additional hog slaughter capacity are greatly affected by a) the entry of a new packer in or near Iowa, b) increases in fuel prices, or c) projected 1990 population distributions.
7. Decreased wage rates increase the possible return on investment in additional hog slaughter facilities in Oklahoma while increased wage rates have an opposite effect.
8. In order to minimize the costs of pork to society, hog slaughter facilities should be located in or near major production areas.

9. There exists excess slaughter capacity in Iowa, Michigan, and the Northeastern and Pacific Coast states.
10. The swine-pork industry is highly competitive.

Limitations

The reliability of the results and conclusions of this study are limited by several factors. Some of these factors were alluded to in Chapter I. However, their discussion in light of the conclusions may more accurately emphasize the relative importance of each one.

Any research project is limited to the extent that data may not be as accurate or detailed as desired. This study is no exception. The most obvious data which may contain errors are slaughter costs. The data used are from a seven-year-old study. There have been many technical advancements since 1974 which may not be reflected. In addition, cost differentials for various slaughter plant sizes are unknown as is the structure (mixture of plant sizes, ages, etc.) of each region's industry.

The study views expansion potential from the viewpoint of relativity in that microeconomic profitability is not considered. For expansion to actually occur, the production and slaughter of hogs must, by necessity, be profitable to the entrepreneurs choosing to engage in these activities.

Demand and supply functions in all regions are assumed to be represented by functions of log linear form. In addition, the elasticities of demand and supply are assumed to apply to all regions. The latter assumption precludes the consideration of changes among regions in factors such as production technology and input price (supply) or tastes and preferences and competitive product prices (demand). These assumptions, obviously, may not be correct.

Neither the availability nor price of production inputs is considered explicitly by estimates of costs for various levels. Increases in production or slaughter in any region will require more inputs and reflect a shift in the demand for these inputs. Input prices may, as a result, increase and thus affect the postulated expansion.

The manual interface between the component computational routines does not allow the simultaneous solution of quantities and prices at some levels of the marketing system. This factor prevents the incorporation of demand functions in the live hog market and thus causes the model to be unable to guarantee the existance of spatial equilibrium prices or shipments of live hogs.

Lastly, the swine-pork industry is considered an island apart from the mainland which is the entire livestock economy. The possible effects of some regions' comparative advantages in other livestock and/or crop enterprises are consequently ignored.

Suggestions for Further Research

Several areas of additional research would further the usefulness and accuracy of the findings of this study. Possibly foremost among these would be a study of the enterprise preferences of Oklahoma's agricultural producers. It seems that swine production is at a great disadvantage in Oklahoma because of the romanticism involved with herds of cattle, fast, beautiful horses, and fields of golden wheat. Whether this apparent bias is real or imaginative has not, to the author's knowledge, been investigated.

The development of a multi-level spatial equilibrium model which yields detailed information concerning trade flows, prices, and opportunity costs at all levels would aid studies of this type immensely. The shortcomings of the manually interfaced model have been discussed. The only multi-level model available did not yield enough of the detailed information needed by this study. A model which includes the theoretical correctness of supply and demand quantities, prices and interregional trade flows which are computed simultaneously and output information concerning the marginal values of all activities (production, processing, consumption and shipment) in the system would be near ideal.

Pork is, by no means, a homogeneous product. Data concerning demand for fresh and cured pork cuts and sausage are available but expensive. An incorporation of these different products into a spatial study would allow an additional sector, pork processing, to be disaggregated. Such a modification may be very useful for studies concerning Oklahoma due to the ongoing adaptation of Wilson Foods Corporation's Oklahoma City facility to processing only.

Lastly, a study of slaughter costs associated with various sizes of plants would greatly increase the accuracy of these data. This type of study would likely have to be done through simulation models based on the engineering characteristics and costs involved with various plant sizes.

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APPENDICES

APPENDIX A

PRODUCTION COSTS FOR LIVE HOGS

TABLE XXXVI

SWINE PRODUCTION COSTS PER HUNDREDWEIGHT IN FARROW-TO-FINISH ENTERPRISES, NORTH CENTRAL, ALL SIZES

Direct costs:		
Grain	$15.028	
Protein supplement	11.936	
Pasture	.023	
Subtotal, feed		$26.987
Veterinary and medicine	$ .735	
Grinding and mixing	.072	
Bedding	.215	
Hauling	.146	
Fuel, lube and electricity	2.140	
Machinery and building repairs	2.199	
Miscellaneous expenses	.505	
Labor (hired and family)	5.439	
Interest on operating capital	.974	
Subtotal, other production items		$12.425
Total, direct costs		$39.412
Ownership costs:		
Machinery and equipment, RITI[1]	$ 1.910	
Buildings and facilities, RITI	4.191	
Livestock, RITI	1.865	
Total, ownership costs		$ 7.966
Other costs:		
Management	$ 3.629	
General farm overhead	2.253	
Land costs	.702	
Total, other costs		$ 6.584
Total costs		$53.962

[1]Replacement, insurance, taxes and interest.

TABLE XXXVII

SWINE PRODUCTION COSTS PER HUNDREDWEIGHT IN FARROW-TO-FINISH ENTERPRISES, SOUTHEAST, ALL SIZES

Direct costs:		
Grain	$16.910	
Protein supplement	11.350	
Pasture	.140	
Subtotal, feed		$28.400
Veterinary and medicine	$ .885	
Grinding and mixing	.450	
Bedding	.113	
Hauling	.123	
Fuel, lube and electricity	1.737	
Machinery and building repairs	2.421	
Miscellaneous expenses	.518	
Labor (hired and family)	6.534	
Interest on operating capital	1.063	
Subtotal, other production items		$13.844
Total, direct costs		$42.244
Ownership costs:		
Machinery and equipment, RITI[1]	$ 2.634	
Buildings and facilities, RITI	3.751	
Livestock, RITI	2.261	
Total, ownership costs		$ 8.646
Other costs:		
Management	$ 3.912	
General farm overhead	2.811	
Land costs	.529	
Total, other costs		$ 7.529
Total costs		$58.142

[1]Replacement, insurance, taxes and interest.

TABLE XXXVIII

SWINE PRODUCTION COSTS PER HUNDREDWEIGHT IN FARROW-TO-FINISH ENTERPRISES, SOUTHWEST, ALL SIZES

Direct Costs:		
Grain	$14.718	
Protein Supplement	11.521	
Pasture	.591	
Sub-total, feed costs		$26.830
Veterinary and medicine	$ .641	
Grinding and mixing	2.196	
Bedding	.021	
Hauling and marketing	1.093	
Fuel, lube and electricity	1.096	
Machinery and building repairs	2.012	
Miscellaneous expenses	.490	
Labor (hired and family)	5.887	
Interest on operating capital	1.067	
Subtotal, other production items		$14.503
Total, direct costs		$41.333
Ownership Costs:		
Machinery and equipment, RITI[1]	$ 1.720	
Buildings and facilities, RITI	4.536	
Livestock, RITI	1.716	
Total, ownership costs		$ 7.972
Other costs:		
Management	$ 3.727	
General farm overhead	1.720	
Land costs	.777	
Total, other costs		$ 6.224
Total costs		$55.529

[1]Replacement, insurance, taxes and interest.

APPENDIX B

MILEAGES AND TRANSPORTATION COSTS

TABLE XXXIX

MILEAGES, EFFECTIVE LIVE TRANSPORT COSTS, AND MEAT TRANSPORT COSTS FOR SHIPMENTS AMONG THE 28 REGIONS

Destination		Region 1, Harrisburg, PA		
	Origin	Dis-tance	Effective Live Transport Rate	Meat Transport Rate
		(miles)	($/cwt.)	($/cwt.)
1.	Harrisburg, PA	-	.50	.75
2.	Raleigh, NC	373	1.20	1.53
3.	Atlanta, GA	701	2.23	2.21
4.	Tallahassee, FL	905	2.86	2.37
5.	Birmingham, AL	796	2.52	2.40
6.	Nashville, TN	718	2.28	2.24
7.	Indianapolis, IN	536	1.71	1.86
8.	Lansing, MI	518	1.66	1.83
9.	Madison, WI	780	2.47	2.37
10.	Springfield, IL	728	2.31	2.26
11.	Little Rock, AR	1063	3.36	2.96
12.	Columbia, MO	889	2.81	2.60
13.	Des Moines, IA	957	3.03	2.74
14.	Minneapolis, MN	1042	3.29	2.92
15.	Bismarck, ND	1641	4.64	3.80
16.	Omaha, NE	1267	3.45	3.02
17.	Topeka, KS	1264	3.42	3.00
18.	Oklahoma City, OK	1454	4.01	3.39
19.	Austin, TX	1727	4.90	3.97
20.	Denver, CO	1783	5.04	4.07
21.	Helena, MT	2235	6.51	5.04
22.	Salt Lake City, UT	2219	6.45	5.00
23.	Phoenix, AZ	2417	7.04	5.39
24.	Sacramento, CA	2884	8.56	5.45
25.	Portland, OR	2904	8.62	6.43
26.	Baton Rouge, LA	1350	3.71	3.19
27.	Baltimore, MD	198	.51	.90
28.	New York City, NY	183	.62	1.13

TABLE XXXIX (Continued)

Destination	Region 2, Raleigh, NC			Region 3, Atlanta, GA			
Origin	Distance	Effective Live Transport Rate	Meat Transport Rate	Origin	Distance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	373	1.20	1.53	1-PA	701	2.23	2.21
2-NC	-	.50	.75	2-NC	372	1.20	1.52
3-GA	372	1.20	1.52	3-GA	-	.50	.75
4-FL	257	1.78	1.78	4-FL	257	.85	1.26
5-AL	522	1.67	1.84	5-AL	150	.52	1.06
6-TN	528	1.69	1.85	6-TN	253	.83	1.28
7-IN	633	2.01	2.07	7-IN	504	1.61	1.80
8-MI	729	2.31	2.26	8-MI	726	3.30	2.26
9-WI	927	2.93	2.68	9-WI	826	2.62	2.47
10-IL	825	2.61	2.46	10-IL	605	1.93	2.01
11-AR	873	2.76	2.56	11-AR	506	1.62	1.80
12-MO	945	2.99	2.71	12-MO	680	2.16	2.16
13-IA	1096	3.46	3.03	13-IA	888	2.81	2.60
14-MN	1189	3.76	3.22	14-MN	1089	3.44	3.01
15-ND	1617	5.10	4.11	15-ND	1517	4.79	3.90
16-NE	1216	3.84	3.28	16-NE	1005	3.18	2.84
17-KS	1137	3.59	3.11	17-KS	872	3.76	2.56
18-OK	1207	3.81	3.26	18-OK	840	2.66	2.50
19-TX	1295	4.09	3.44	19-TX	923	2.92	2.67
20-CO	1682	5.31	4.24	20-CO	1410	4.45	3.68
21-MT	2211	6.98	5.34	21-MT	2049	6.46	5.01
22-UT	2162	6.82	5.24	22-UT	1907	6.02	4.71
23-AZ	2172	6.85	5.26	23-AZ	1800	5.68	4.49
24-CA	2827	8.93	5.65	24-CA	2495	7.88	5.08
25-OR	2880	9.10	6.73	25-OR	2648	8.36	6.25
26-LA	901	2.85	2.62	26-LA	529	1.69	1.85
27-MD	302	.96	1.38	27-MD	651	2.07	2.10
28-NY	500	1.60	1.79	28-NY	849	2.69	2.51

TABLE XXXIX (Continued)

Destination Region 4, Tallahassee, FL				Region 5, Birmingham, AL			
Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate	Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	905	2.86	2.63	1-PA	796	2.52	2.63
2-NC	559	1.78	1.91	2-NC	522	1.67	1.91
3-GA	257	.85	1.28	3-GA	150	.52	1.23
4-FL	-	.50	.82	4-FL	298	.97	.82
5-AL	298	.97	1.37	5-AL	-	.50	1.37
6-TN	495	1.58	1.78	6-TN	205	.68	1.78
7-IN	758	2.40	2.32	7-IN	477	1.53	2.32
8-MI	980	3.10	2.79	8-MI	713	2.26	2.79
9-WI	1068	3.38	2.97	9-WI	778	2.47	2.97
10-IL	1180	3.73	3.20	10-IL	538	1.72	3.20
11-AR	673	2.14	2.15	11-AR	384	1.24	2.15
12-MO	885	2.80	2.59	12-MO	587	1.87	2.59
13-IA	1099	3.47	3.03	13-IA	801	2.54	3.03
14-MN	1321	4.17	3.49	14-MN	1023	3.23	3.49
15-ND	1749	5.52	4.38	15-ND	1451	4.58	4.38
16-NE	1193	3.77	3.23	16-NE	904	2.86	3.23
17-KS	1045	3.30	2.92	17-KS	756	2.40	2.92
18-OK	995	3.15	2.82	18-OK	718	2.28	2.82
19-TX	896	2.84	2.61	19-TX	773	2.45	2.61
20-CO	1577	4.98	4.03	20-CO	1288	4.07	4.03
21-MT	2248	7.09	5.42	21-MT	1959	6.18	5.42
22-UT	2070	6.53	5.05	22-UT	1785	5.63	5.05
23-AZ	1832	5.78	4.56	23-AZ	1650	5.21	4.56
24-CA	2576	8.13	5.22	24-CA	2371	7.48	5.22
25-OR	2830	8.94	6.63	25-OR	2541	8.02	6.63
26-LA	459	1.47	1.70	26-LA	379	1.22	1.70
27-MD	855	2.71	2.53	27-MD	773	2.45	2.53
28-NY	1053	3.33	2.94	28-NY	971	3.07	2.94

TABLE XXXIX (Continued)

Destination	Region 6, Nashville, TN			Region 7, Indianapolis, IN			
Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate	Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	718	2.28	2.24	1-PA	536	1.71	1.86
2-NC	528	1.69	1.85	2-NC	633	2.01	2.07
3-GA	253	.83	1.28	3-GA	504	1.61	1.80
4-FL	495	1.58	1.68	4-FL	758	2.40	2.12
5-AL	205	.68	1.18	5-AL	477	1.53	1.74
6-TN	-	.50	.75	6-TN	288	.94	1.35
7-IN	288	.94	1.35	7-IN	-	.50	.75
8-MI	524	1.67	1.84	8-MI	247	.82	1.26
9-WI	573	1.83	1.94	9-WI	327	1.06	1.43
10-IL	352	1.14	1.48	10-IL	192	.64	1.15
11-AR	345	1.12	1.47	11-AR	557	1.78	1.91
12-MO	427	1.37	1.64	12-MO	353	1.14	1.46
13-IA	635	2.02	2.07	13-IA	467	1.50	1.72
14-MN	836	2.65	2.49	14-MN	589	1.88	1.98
15-ND	1264	3.99	3.38	15-ND	1017	3.22	2.86
16-NE	752	2.39	2.31	16-NE	587	1.87	1.97
17-KS	619	1.97	2.04	17-KS	545	1.74	1.88
18-OK	679	2.16	2.16	18-OK	735	2.33	2.28
19-TX	834	2.64	2.48	19-TX	1046	3.31	2.92
20-CO	1164	3.68	3.17	20-CO	1064	3.36	2.96
21-MT	1796	5.67	4.48	21-MT	1611	5.08	4.10
22-UT	1657	5.23	4.19	22-UT	1533	4.84	3.93
23-AZ	1659	5.23	4.20	23-AZ	1698	5.36	4.28
24-CA	2322	7.33	4.79	24-CA	2198	6.94	4.58
25-OR	2395	7.56	5.72	25-OR	2271	7.17	5.47
26-LA	543	1.73	1.88	26-LA	803	2.54	2.42
27-MD	695	2.21	2.20	27-MD	564	1.80	1.92
28-NY	893	2.83	2.61	28-NY	719	2.28	2.24

TABLE XXXIX (Continued)

Destination	Region 8, Lansing, MI			Region 9, Madison, WI			
Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate	Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	$/cwt.)		(miles)	($/cwt.)	$/cwt.)
1-PA	518	1.66	1.83	1-PA	780	2.47	2.37
2-NC	729	2.31	2.26	2-NC	927	2.93	2.68
3-GA	726	2.30	2.26	3-GA	826	2.62	2.47
4-FL	980	3.10	2.50	4-FL	1086	3.38	2.65
5-AL	713	2.26	2.23	5-AL	778	2.47	2.37
6-TN	524	1.67	1.84	6-TN	573	1.83	1.94
7-IN	247	.82	1.26	7-IN	327	1.06	1.43
8-MI	-	.50	.75	8-MI	347	1.12	1.47
9-WI	347	1.12	1.47	9-WI	-	.50	.75
10-IL	378	1.22	1.54	10-IL	259	.85	1.29
11-AR	804	2.55	2.42	11-AR	713	2.26	2.23
12-MO	567	1.81	1.93	12-MO	424	1.36	1.63
13-IA	527	1.68	1.85	13-IA	284	.93	1.34
14-MN	609	1.94	2.02	14-MN	267	.88	1.31
15-ND	1037	3.28	2.94	15-ND	695	2.21	2.20
16-NE	663	2.11	2.13	16-NE	420	1.35	1.62
17-KS	754	2.39	2.32	17-KS	540	1.72	1.87
18-OK	975	3.08	2.78	18-OK	825	2.61	2.46
19-TX	1293	4.08	3.44	19-TX	1162	3.67	3.16
20-CO	1203	3.80	3.25	20-CO	959	3.03	2.74
21-MT	1631	5.15	4.14	21-MT	1289	4.07	3.43
22-UT	1615	5.10	4.10	22-UT	1371	4.33	3.60
23-AZ	1908	6.02	4.71	23-AZ	1694	5.34	4.27
24-CA	1239	7.20	4.72	24-CA	2036	6.42	4.30
25-OR	2300	7.26	5.53	25-OR	1958	6.18	4.82
26-LA	1050	3.32	2.93	26-LA	992	3.14	2.81
27-MD	546	1.74	1.89	27-MD	808	2.56	2.43
28-NY	689	2.19	2.18	28-NY	951	3.01	2.73

TABLE XXXIX (Continued)

Destination Region 10, Springfield, IL				Region 11, Little Rock, AR			
Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate	Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	728	2.31	2.26	1-PA	1238	3.36	2.96
2-NC	825	2.61	2.46	2-NC	872	2.76	2.56
3-GA	605	1.93	5.01	3-GA	506	1.62	1.80
4-FL	1180	3.73	2.84	4-FL	673	2.14	1.97
5-AL	538	1.72	1.87	5-AL	384	1.24	1.55
6-TN	352	1.14	1.48	6-TN	345	1.12	1.47
7-IN	192	.64	1.15	7-IN	557	1.78	1.91
8-MI	378	1.22	1.54	8-MI	804	2.55	2.42
9-WI	259	.85	1.29	9-WI	713	2.26	2.23
10-IL	-	.50	.75	10-IL	454	1.46	1.69
11-AR	454	1.46	1.69	11-AR	-	.50	.75
12-MO	189	.64	1.14	12-MO	384	1.24	1.55
13-IA	290	.95	1.35	13-IA	561	1.79	1.92
14-MN	487	1.56	1.76	14-MN	811	2.57	2.44
15-ND	915	2.90	2.65	15-ND	1173	3.70	3.19
16-NE	410	1.32	1.60	16-NE	595	1.90	1.99
17-KS	1385	4.37	3.63	17-KS	447	1.44	1.68
18-OK	602	1.92	2.00	18-OK	342	1.11	1.46
19-TX	929	2.94	2.68	19-TX	489	1.56	1.77
20-CO	872	2.76	2.56	20-CO	952	3.01	2.73
21-MT	1451	4.58	3.76	21-MT	1650	5.21	4.18
22-UT	1352	4.27	3.56	22-UT	1442	4.55	3.74
23-AZ	1530	4.83	3.93	23-AZ	1322	4.17	3.50
24-CA	2017	6.36	4.27	24-CA	1997	6.30	4.23
25-OR	2090	6.59	5.09	25-OR	2223	7.01	5.37
26-LA	738	2.34	2.28	26-LA	357	1.16	1.49
27-MD	756	2.40	2.32	27-MD	1040	3.29	2.91
28-NY	911	2.88	2.64	28-NY	1238	3.91	3.32

TABLE XXXIX (Continued)

Destination Region 12, Columbia, MO				Region 13, Des Moines, IA			
Origin	Distance	Effective Live Transport Rate	Meat Transport Rate	Origin	Distance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	889	2.81	2.60	1-PA	957	3.03	2.74
2-NC	945	2.99	2.71	2-NC	1096	3.46	3.03
3-GA	680	2.16	2.16	3-GA	888	2.81	2.60
4-FL	885	2.80	2.34	4-FL	1099	3.47	2.70
5-AL	587	1.87	1.97	5-AL	801	2.54	2.42
6-TN	427	1.37	1.64	6-TN	635	2.02	2.07
7-IN	353	1.14	1.48	7-IN	467	1.50	1.72
8-MI	567	1.81	1.93	8-MI	527	1.68	1.85
9-WI	424	1.36	1.63	9-WI	284	.93	1.34
10-IL	189	.64	1.14	10-IL	290	.95	1.35
11-AR	384	1.24	1.55	11-AR	561	1.79	1.92
12-MO	-	.50	.75	12-MO	243	.80	1.62
13-IA	243	.80	1.26	13-IA	-	.50	.75
14-MN	476	1.52	1.74	14-MN	250	.82	1.27
15-ND	903	2.86	2.63	15-ND	666	2.12	2.13
16-NE	329	1.07	1.44	16-NE	139	.52	1.04
17-KS	192	.64	1.15	17-KS	258	.85	1.29
18-OK	447	1.44	1.68	18-OK	547	1.75	1.89
19-TX	774	2.45	2.34	19-TX	884	2.80	2.59
20-CO	737	2.34	2.28	20-CO	679	2.16	2.16
21-MT	1384	4.37	3.62	21-MT	1161	3.67	3.16
22-UT	1230	3.88	3.30	22-UT	1091	3.45	3.02
23-AZ	1345	4.24	3.54	23-AZ	1416	4.47	3.69
24-CA	1895	5.98	4.06	24-CA	1756	5.54	3.82
25-OR	1968	6.21	4.84	25-OR	1829	5.77	4.55
26-LA	732	2.32	2.27	26-LA	917	2.90	2.66
27-MD	917	2.90	2.66	27-MD	985	3.12	2.80
28-NY	1072	3.39	2.98	28-NY	1131	3.57	3.10

TABLE XXXIX (Continued)

Destination Region 14, Minneapolis, MN				Region 15, Bismarck, ND			
Origin	Distance	Effective Live Transport Rate	Meat Transport Rate	Origin	Distance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	1042	3.29	2.92	1-PA	1470	4.64	3.08
2-NC	1189	3.76	3.22	2-NC	1617	5.10	4.11
3-GA	1089	3.44	3.01	3-GA	1517	4.79	3.90
4-FL	1321	4.17	3.08	4-FL	1749	5.52	3.81
5-AL	1023	3.23	2.88	5-AL	1451	4.58	3.76
6-TN	836	2.65	2.49	6-TN	1264	4.00	3.38
7-IN	589	1.88	1.98	7-IN	1017	3.22	2.86
8-MI	609	1.94	2.02	8-MI	1037	3.28	2.90
9-WI	267	.88	1.31	9-WI	695	2.21	2.20
10-IL	487	1.56	1.76	10-IL	915	2.90	2.65
11-AR	811	2.57	2.44	11-AR	1173	3.70	3.19
12-MO	476	1.52	1.74	12-MO	903	2.86	2.63
13-IA	250	.82	1.27	13-IA	666	2.12	2.13
14-MN	-	.50	.75	14-MN	428	1.38	1.64
15-ND	428	1.38	1.64	15-ND	-	.50	.75
16-NE	360	1.16	1.50	16-NE	581	1.85	1.96
17-KS	508	1.62	1.81	17-KS	746	2.38	2.30
18-OK	797	2.53	2.41	18-OK	948	3.00	2.72
19-TX	1134	3.58	3.11	19-TX	1346	4.25	3.55
20-CO	845	2.68	2.51	20-CO	675	2.14	2.15
21-MT	1022	3.23	2.87	21-MT	622	1.98	2.04
22-UT	1215	3.84	3.27	22-UT	926	2.93	2.67
23-AZ	1618	5.10	4.11	23-AZ	1467	4.63	3.80
24-CA	1880	5.93	4.03	24-CA	1534	4.84	3.44
25-OR	1691	5.34	4.26	25-OR	1272	4.02	3.93
26-LA	1167	3.69	3.18	26-LA	1529	4.82	3.93
27-MD	1070	3.38	2.97	27-MD	1498	4.73	3.86
28-NY	1213	3.83	3.27	28-NY	1641	5.18	4.16

TABLE XXXIX (Continued)

Destination	Region 16, Omaha, NE			Region 17, Topeka, KS			
Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate	Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	1093	3.45	3.02	1-PA	1081	3.42	3.00
2-NC	1216	3.84	3.28	2-NC	1137	3.59	3.11
3-GA	1005	3.18	2.84	3-GA	872	2.76	2.56
4-FL	1193	3.77	2.86	4-FL	1045	3.30	2.61
5-AL	904	2.86	2.63	5-AL	756	2.40	2.32
6-TN	752	2.39	2.31	6-TN	619	1.97	2.04
7-IN	587	1.87	1.97	7-IN	545	1.74	1.88
8-MI	663	2.11	2.13	8-MI	754	2.39	2.32
9-WI	420	1.34	1.62	9-WI	540	1.72	1.87
10-IL	410	1.32	1.60	10-IL	1385	4.37	3.63
11-AR	595	1.90	1.99	11-AR	447	1.44	1.68
12-MO	329	1.07	1.44	12-MO	192	.64	1.15
13-IA	139	.52	1.04	13-IA	258	.85	1.29
14-MN	360	1.16	1.50	14-MN	508	1.62	1.81
15-ND	581	1.85	1.96	15-ND	746	2.37	2.30
16-NE	-	.50	.75	16-NE	165	.56	1.09
17-KS	165	.56	1.09	17-KS	-	.50	.75
18-OK	453	1.45	1.69	18-OK	290	.95	1.35
19-TX	843	2.67	2.50	19-TX	680	2.16	2.16
20-CO	540	1.72	1.87	20-CO	545	1.74	1.88
21-MT	1055	3.34	2.94	21-MT	1219	3.85	3.28
22-UT	952	3.01	2.73	22-UT	1047	3.31	2.93
23-AZ	1296	4.09	3.44	23-AZ	1159	3.66	3.16
24-CA	1617	5.10	3.56	24-CA	1712	5.40	3.75
25-OR	1690	5.33	4.26	25-OR	1785	5.63	4.46
26-LA	951	3.01	2.73	26-LA	803	2.54	2.42
27-MD	1121	3.54	3.08	27-MD	1109	3.50	3.05
28-NY	1267	4.00	3.38	28-NY	1264	3.99	3.38

TABLE XXXIX (Continued)

Destination Region 18, Oklahoma City, OK				Region 19, Austin, TX			
Origin	Dis-tance	Effective Live Transport Rate	Meat Transport Rate	Origin	Dis-tance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	1271	4.01	3.39	1-PA	1552	4.90	3.97
2-NC	1207	3.81	3.26	2-NC	1295	4.09	3.44
3-GA	840	2.66	2.50	3-GA	923	2.92	2.67
4-FL	995	3.15	2.52	4-FL	896	2.84	2.35
5-AL	718	2.28	2.24	5-AL	773	2.45	2.36
6-TN	679	2.16	2.17	6-TN	834	2.64	2.48
7-IN	735	2.33	2.29	7-IN	1046	3.31	2.92
8-MI	975	3.08	2.78	8-MI	1293	4.08	3.44
9-WI	825	2.61	2.46	9-WI	1162	3.67	3.16
10-IL	602	1.92	2.00	10-IL	929	2.94	2.68
11-AR	342	1.11	1.46	11-AR	489	1.56	1.77
12-MO	447	1.44	1.68	12-MO	774	2.45	2.36
13-IA	547	1.75	1.89	13-IA	884	2.80	2.59
14-MN	797	2.53	2.41	14-MN	1134	3.58	3.11
15-ND	948	3.00	2.72	15-ND	1346	4.25	3.55
16-NE	453	1.45	1.69	16-NE	843	2.67	2.50
17-KS	290	.95	1.35	17-KS	680	2.16	2.16
18-OK	-	.50	.75	18-OK	400	1.29	1.58
19-TX	400	1.29	1.58	19-TX	-	.50	.75
20-CO	610	1.94	2.02	20-CO	910	2.88	2.64
21-MT	1371	4.33	3.60	21-MT	1689	5.33	4.26
22-UT	1100	3.47	3.04	22-UT	1298	4.10	3.45
23-AZ	980	3.10	2.79	23-AZ	983	3.11	2.79
24-CA	1655	5.22	3.65	24-CA	1752	5.53	3.82
25-OR	1881	5.93	4.66	25-OR	2092	6.60	5.10
26-LA	602	1.92	2.00	26-LA	440	1.41	1.67
27-MD	1299	4.10	3.45	27-MD	1529	4.82	3.92
28-NY	1454	4.59	3.77	28-NY	1727	5.45	4.34

TABLE XXXIX (Continued)

Destination	Region 20, Denver, CO				Region 21, Helena, MT		
Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate	Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	1600	5.05	4.07	1-PA	2064	6.51	5.04
2-NC	1682	5.31	4.24	2-NC	2211	6.98	5.34
3-GA	1410	4.45	3.68	3-GA	2049	6.47	5.01
4-FL	1577	4.98	3.52	4-FL	2248	7.09	4.66
5-AL	1288	4.07	3.43	5-AL	1959	6.18	4.82
6-TN	1164	4.68	3.17	6-TN	1796	5.67	4.48
7-IN	1064	3.36	2.96	7-IN	1611	5.08	4.10
8-MI	1203	3.80	3.25	8-MI	1631	5.15	4.14
9-WI	959	3.03	2.74	9-WI	1289	4.07	3.43
10-IL	872	2.76	2.56	10-IL	1451	4.58	3.76
11-AR	952	3.01	2.73	11-AR	1650	5.21	4.18
12-MO	737	2.34	2.28	12-MO	1384	4.37	3.63
13-IA	679	2.16	2.16	13-IA	1161	3.67	3.16
14-MN	845	2.68	2.51	14-MN	1022	3.23	2.87
15-ND	675	2.15	2.15	15-ND	622	1.98	2.04
16-NE	540	1.72	1.87	16-NE	1055	3.34	2.94
17-KS	545	1.74	1.88	17-KS	1219	3.85	3.28
18-OK	610	1.95	2.02	18-OK	1371	4.33	3.60
19-TX	910	2.88	2.64	19-TX	1689	5.33	4.26
20-CO	-	.50	.75	20-CO	785	2.49	2.38
21-MT	785	2.49	2.38	21-MT	-	.50	.75
22-UT	504	1.61	1.80	22-UT	477	1.53	1.74
23-AZ	792	2.51	2.40	23-AZ	1128	3.56	3.09
24-CA	1169	3.69	2.82	24-CA	1009	3.19	2.55
25-OR	1275	4.03	3.99	25-OR	669	2.13	2.12
26-LA	1202	3.80	3.25	26-LA	1973	6.22	4.85
27-MD	1628	5.14	4.13	27-MD	2092	6.60	5.10
28-NY	1783	5.63	4.45	28-NY	2235	7.05	5.39

TABLE XXXIX (Continued)

Destination Region 22, Salt Lake City, UT				Region 23, Phoenix, AZ			
Origin	Distance	Effective Live Transport Rate	Meat Transport Rate	Origin	Distance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	2045	6.45	5.00	1-PA	2234	7.05	5.39
2-NC	2162	6.82	5.24	2-NC	2172	6.85	5.26
3-GA	1907	6.02	4.71	3-GA	1800	5.68	4.49
4-FL	2070	6.53	4.36	4-FL	1832	5.78	3.95
5-AL	1785	5.63	4.46	5-AL	1650	5.21	4.18
6-TN	1657	5.23	4.19	6-TN	1659	5.23	4.20
7-IN	1533	4.84	3.93	7-IN	1698	5.36	4.28
8-MI	1615	5.10	4.11	8-MI	1908	6.02	4.71
9-WI	1371	4.33	3.60	9-WI	1694	5.34	4.27
10-IL	1352	4.27	3.56	10-IL	1530	4.83	3.93
11-AR	1442	4.55	3.75	11-AR	1322	4.17	3.50
12-MO	1230	3.88	3.31	12-MO	1345	4.25	3.54
13-IA	1091	3.45	3.02	13-IA	1416	4.47	3.69
14-MN	1215	3.84	3.27	14-MN	1618	5.11	4.11
15-ND	926	2.93	2.67	15-ND	1467	4.63	3.80
16-NE	952	3.01	2.73	16-NE	1296	4.09	3.44
17-KS	1047	3.31	2.93	17-KS	1159	3.66	3.16
18-OK	1100	3.48	3.04	18-OK	980	3.10	2.79
19-TX	1298	4.10	3.45	19-TX	983	3.11	2.79
20-CO	504	1.61	1.80	20-CO	792	2.51	2.40
21-MT	477	1.53	1.74	21-MT	1128	3.56	3.09
22-UT	-	.50	.75	22-UT	651	2.07	2.10
23-AZ	651	2.07	2.11	23-AZ	-	.50	.75
24-CA	665	2.11	1.96	24-CA	769	2.44	2.13
25-OR	794	2.52	2.40	25-OR	1268	4.00	3.38
26-LA	1657	5.21	4.19	26-LA	1417	4.47	3.69
27-MD	2073	6.54	5.06	27-MD	2262	7.14	5.45
28-NY	2219	7.00	5.36	28-NY	2417	7.63	5.77

TABLE XXXIX (Continued)

Destination Region 24, Sacramento, CA				Region 25, Portland, OR			
Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate	Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	2710	8.56	6.38	1-PA	2733	8.63	6.43
2-NC	2827	8.93	6.62	2-NC	2880	9.10	6.73
3-GA	2495	7.88	5.93	3-GA	2648	8.36	6.25
4-FL	2576	8.13	5.22	4-FL	2830	8.94	5.66
5-AL	2371	7.48	5.67	5-AL	2541	8.02	6.03
6-TN	2322	7.33	5.57	6-TN	2395	7.56	5.72
7-IN	2198	6.94	5.32	7-IN	2271	7.71	5.47
8-MI	2280	7.20	5.49	8-MI	2300	7.26	5.53
9-WI	2036	6.42	4.98	9-WI	1958	6.18	4.82
10-IL	2017	6.36	4.94	10-IL	2090	6.59	5.09
11-AR	1997	6.30	4.90	11-AR	2223	7.01	5.37
12-MO	1895	5.98	4.69	12-MO	1968	6.21	4.84
13-IA	1756	5.54	4.40	13-IA	1829	5.77	4.55
14-MN	1880	5.93	4.66	14-MN	1691	5.34	4.26
15-ND	1534	4.84	3.94	15-ND	1272	4.02	3.39
16-NE	1617	5.10	4.11	16-NE	1690	5.33	4.26
17-KS	1712	5.40	4.31	17-KS	1785	5.63	4.46
18-OK	1655	5.22	4.19	18-OK	1881	5.93	4.66
19-TX	1752	5.53	4.39	19-TX	2092	6.60	5.10
20-CO	1169	3.69	3.18	20-CO	1275	4.03	3.40
21-MT	1009	3.19	2.85	21-MT	669	2.13	2.14
22-UT	665	2.11	2.13	22-UT	794	2.52	2.40
23-AZ	769	2.44	2.35	23-AZ	1268	4.00	3.38
24-CA	-	.50	.75	24-CA	580	1.85	1.82
25-OR	580	1.85	1.96	25-OR	-	.50	.75
26-LA	2163	6.83	5.24	26-LA	2451	7.74	5.84
27-MD	2738	8.65	6.44	27-MD	2761	8.72	6.48
28-NY	2884	9.11	6.74	28-NY	2904	9.17	6.78

TABLE XXXIX (Continued)

Destination Region 26, Baton Rouge, LA				Region 27, Baltimore, MD			
Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate	Origin	Dis- tance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)		(miles)	($/cwt.)	($/cwt.)
1-PA	1175	3.71	3.19	1-PA	71	.51	.90
2-NC	901	2.85	2.62	2-NC	302	.99	1.38
3-GA	529	1.69	1.85	3-GA	651	2.07	2.10
4-FL	459	1.47	1.61	4-FL	855	2.71	2.28
5-AL	379	1.22	1.54	5-AL	773	2.45	2.36
6-TN	543	1.73	1.88	6-TN	695	2.21	2.20
7-IN	803	2.55	2.42	7-IN	564	1.80	1.92
8-MI	1050	3.32	2.93	8-MI	546	1.74	1.89
9-WI	992	3.14	2.81	9-WI	808	2.56	2.43
10-IL	738	2.34	2.28	10-IL	756	2.40	2.32
11-AR	357	1.16	1.49	11-AR	1040	3.29	2.91
12-MO	732	2.32	2.27	12-MO	917	2.90	2.66
13-IA	917	2.90	2.66	13-IA	985	3.12	2.80
14-MN	1167	3.69	3.18	14-MN	1070	3.38	2.97
15-ND	1529	4.82	3.93	15-ND	1498	4.73	3.86
16-NE	951	3.01	2.73	16-NE	1121	3.54	3.08
17-KS	803	2.55	2.42	17-KS	1109	3.50	3.05
18-OK	602	1.92	2.00	18-OK	1299	4.10	3.45
19-TX	440	1.41	1.67	19-TX	1529	4.82	3.93
20-CO	1202	3.80	3.25	20-CO	1628	5.14	4.13
21-MT	1973	6.22	4.85	21-MT	2092	6.60	5.09
22-UT	1657	5.21	4.19	22-UT	2073	6.54	5.06
23-AZ	1417	4.47	3.69	23-AZ	2262	7.14	5.45
24-CA	2163	6.83	4.52	24-CA	2738	8.64	5.50
25-OR	2451	7.74	5.84	25-OR	2761	8.72	6.48
26-LA	-	.50	.75	26-LA	1152	3.64	3.14
27-MD	1152	3.64	3.14	27-MD	-	.50	.75
28-NY	1350	4.26	3.55	28-NY	198	.66	1.16

TABLE XXXIX (Continued)

Destination Region 28, New York, NY

Origin	Distance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)
1-PA	183	.62	1.13
2-NC	500	1.60	1.79
3-GA	849	2.69	2.51
4-FL	1053	3.33	2.62
5-AL	971	3.07	2.77
6-TN	893	2.83	2.61
7-IN	719	2.28	2.24
8-MI	689	2.19	2.18
9-WI	951	3.01	2.73
10-IL	911	2.88	2.64
11-AR	1238	3.91	3.32
12-MO	1072	3.39	2.98
13-IA	1131	3.57	3.10
14-MN	1213	3.83	3.27
15-ND	1641	5.18	4.16
16-NE	1267	4.00	3.38
17-KS	1264	3.99	3.38
18-OK	1454	4.59	3.77
19-TX	1727	5.45	4.34
20-CO	1783	5.63	4.45
21-MT	2235	7.05	5.39
22-UT	2219	7.00	5.36
23-AZ	2417	7.63	5.77
24-CA	2884	9.11	5.75
25-OR	2904	9.17	6.78
26-LA	1350	4.26	3.55
27-MD	198	.66	1.16
28-NY	-	.50	.75

TABLE XL

MILEAGES, EFFECTIVE LIVE TRANSPORT COSTS TO AND MEAT TRANSPORT COSTS FROM OMAHA, NEBRASKA, FROM AND TO THE 28 REGIONS

Region	Distance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)
1-PA	1093	3.29	3.02
2-NC	1216	3.66	3.28
3-GA	1005	3.02	2.84
4-FL	1193	3.59	2.86
5-AL	904	2.72	2.63
6-TN	752	2.26	2.31
7-IN	587	1.76	1.97
8-MI	663	1.99	2.13
9-WI	420	1.25	1.62
10-IL	410	1.21	1.60
11-AR	595	1.78	1.99
12-MO	329	.97	1.44
13-IA	139	.52	1.04
14-MN	360	1.07	1.50
15-ND	581	1.74	1.96
16-NE	-	.50	.75
17-KS	165	.56	1.09
18-OK	453	1.35	1.69
19-TX	843	2.53	2.50
20-CO	540	1.61	1.87
21-MT	1055	3.17	2.94
22-UT	952	2.86	2.73
23-AZ	1296	3.90	2.44
24-CA	1617	4.88	3.59
25-CA	1690	5.10	4.26
26-LA	951	2.86	2.73
27-LA	1121	3.37	3.08
28-NY	1267	3.82	3.38

TABLE XLI

MILEAGES, EFFECTIVE LIVE TRANSPORT COSTS TO AND MEAT TRANSPORT COSTS FROM KIRKSVILLE, MISSOURI, FROM AND TO THE 28 REGIONS

Region	Distance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)
1-PA	909	2.73	2.64
2-NC	1002	3.01	2.83
3-GA	754	2.26	2.32
4-FL	964	2.90	2.47
5-AL	666	1.99	2.13
6-TN	501	1.49	1.79
7-IN	373	1.11	1.53
8-MI	541	1.62	1.88
9-WI	332	.98	1.44
10-IL	181	.52	1.13
11-AR	471	1.40	1.73
12-MO	94	.51	.95
13-IA	149	.52	1.06
14-MN	382	1.13	1.55
15-ND	809	2.43	2.43
16-NE	256	.75	1.28
17-KS	221	.65	1.21
18-OK	506	1.51	1.80
19-TX	843	2.53	2.50
20-CO	711	2.13	2.23
21-MT	1306	3.93	3.46
22-UT	1187	3.57	3.22
23-AZ	1375	4.14	3.61
24-CA	1852	5.59	3.99
25-OR	1925	5.81	4.75
26-LA	826	2.48	2.47
27-MD	937	2.82	2.70
28-NY	1092	3.29	3.02

TABLE XLII

MILEAGES, EFFECTIVE LIVE TRANSPORT COSTS TO AND MEAT TRANSPORT COSTS FROM ALBERT LEA, MINNESOTA, FROM AND TO THE 28 REGIONS

Region	Distance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)
1-PA	1015	3.05	2.86
2-NC	1162	3.50	3.16
3-GA	1016	3.06	2.86
4-FL	1235	3.72	2.93
5-AL	937	2.82	2.70
6-TN	763	2.29	2.34
7-IN	562	1.68	1.92
8-MI	582	1.74	1.96
9-WI	250	.73	1.27
10-IL	411	1.22	1.61
11-AR	712	2.13	2.23
12-MO	379	1.12	1.54
13-IA	151	.52	1.06
14-MN	100	.51	.96
15-ND	524	1.56	1.84
16-NE	279	.82	1.33
17-KS	409	1.22	1.60
18-OK	698	2.09	2.20
19-TX	1035	3.11	2.90
20-CO	785	2.36	2.38
21-MT	1065	3.20	2.96
22-UT	1173	3.53	3.19
23-AZ	1558	4.70	3.99
24-CA	1838	5.55	3.96
25-OR	1734	5.23	4.35
26-LA	1068	3.21	2.97
27-MD	1043	3.14	2.92
28-NY	1186	3.57	3.21

TABLE XLIII

MILEAGES, EFFECTIVE LIVE TRANSPORT COSTS TO AND MEAT TRANSPORT COSTS FROM DAVENPORT, IOWA, FROM AND TO THE 28 REGIONS

Region	Distance	Effective Live Transport Rate	Meat Transport Rate
	(miles)	($/cwt.)	($/cwt.)
1-PA	792	2.38	2.40
2-NC	934	2.81	2.69
3-GA	757	2.27	2.32
4-FL	988	2.97	2.51
5-AL	690	2.07	2.18
6-TN	504	1.50	1.80
7-IN	308	.91	1.39
8-MI	364	1.08	1.51
9-WI	165	.52	1.09
10-IL	152	.51	1.07
11-AR	582	1.74	1.96
12-MO	263	.77	1.30
13-IA	167	.52	1.10
14-MN	329	.97	1.44
15-ND	763	2.29	2.34
16-NE	303	.89	1.38
17-KS	401	1.19	1.58
18-OK	686	2.06	2.18
19-TX	1023	3.08	2.88
20-CO	843	2.53	2.50
21-MT	1316	3.96	3.48
22-UT	1255	3.78	3.36
23-AZ	1555	4.69	3.98
24-CA	1920	5.79	4.10
25-OR	1985	5.99	4.87
26-LA	882	2.65	2.58
27-MD	820	2.46	2.45
28-NY	968	2.91	2.76

APPENDIX C

OPTIMAL SHIPMENT PATTERNS

TABLE XLIV

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR PRODUCTION, SLAUGHTER, AND CONSUMPTION REQUIRED IN ALL REGIONS AT 1979 LEVELS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT CLOSED

Region	Intraregional Shipments	Exporting Regions														Total Live Hog Demands
		3-GA	4-FL	7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	20-CO	23-AZ	27-MD	
								(mil. lbs., live)								
1-PA	231.46			335.78				275.43							2.64	845.31
2-NC	1102.75	193.83	113.03													1409.61
3-GA	649.95															649.95
4-FL	33.61															33.61
5-AL	460.12	1.63					101.65	138.92								702.32
6-TN	1031.77							376.40								1408.20
7-IN	2103.02															2103.02
8-MI	339.30			175.49	62.81	760.97										1338.57
9-WI	589.65															589.65
10-IL	2077.95															2077.95
11-AR	64.37															64.37
12-MO	866.53															866.53
13-IA	5956.63							.11	333.82		154.86					6445.42
14-MN	1448.66															1448.66
15-ND	7.55															7.55
16-NE	2147.61															2147.61
17-KS	388.40															388.40
18-OK	124.47											181.87				306.34
19-TX	353.33						45.80									399.13
20-CO	128.85															128.85
21-MT	116.98									33.56						150.54
22-UT	18.53												15.47			34.00
23-AZ	66.88															66.88
24-CA	85.44										93.23	239.10	15.82	16.59		450.18
25-OR	75.78								50.42	73.86						200.06
26-LA	43.88						7.44									51.32
27-MD	110.56															110.56
28-NY	102.63							57.47								160.10
TOTAL	20726.66	195.46	113.03	511.27	62.81	760.97	154.89	848.36	384.24	107.42	248.09	420.97	31.29	16.59	2.64	24584.69

TABLE XLV

OPTIMAL MEAT SHIPMENT PATTERNS FOR PRODUCTION, SLAUGHTER, AND CONSUMPTION REQUIRED IN ALL REGIONS AT 1979 LEVELS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT CLOSED

Region	Intraregional Shipments	Exporting Regions 2-NC	6-TN	7-IN	8-MI	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	Total Pork Demands
	(mil. lbs., carcass)												
1-PA	525.04			160.95									685.99
2-NC	869.54												869.54
3-GA	403.70		75.03				169.14						647.87
4-FL	20.88								692.27				713.15
5-AL	436.22						190.57						676.79
6-TN	799.63												799.63
7-IN	1054.25												1054.25
8-MI	601.73												601.73
9-WI	308.48												308.48
10-IL	733.88												733.88
11-AR	39.98								124.99				164.97
12-MO	370.55												370.55
13-IA	220.95												220.95
14-MN	309.11												309.11
15-ND	4.69									45.33			50.02
16-NE	172.29												172.29
17-KS	180.37												180.37
18-OK	190.28											28.57	218.85
19-TX	247.90								764.62				1012.52
20-CO	80.03										104.32		184.35
21-MT	93.50									48.88			142.38
22-UT	21.12										116.48		137.60
23-AZ	41.54										171.62	32.30	245.46
24-CA	279.62								314.61		769.20		1363.43
25-OR	124.26									263.43			387.69
26-LA	31.88							167.67	104.51				304.06
27-MD	68.67	5.99		91.03			197.07		221.93				584.69
28-NY	99.44				229.69	57.77			1559.48	233.04			2179.42
TOTAL	8329.53	5.99	75.03	251.98	229.69	57.77	556.78	167.67	3782.41	590.68	1161.62	60.87	15270.02

TABLE XLVI

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR REQUIRED PRODUCTION AND CONSUMPTION AND VARIABLE SLAUGHTER IN ALL REGIONS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT OPEN

Region	Intraregional Shipments	Exporting Regions 3-GA	4-FL	7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	20-CO	23-AZ	Total Live Hog Demands
	(mil. lbs., live)														
1-PA	231.60														231.60
2-NC	1100.36		21.40	233.84											1355.60
3-GA	769.47														769.47
4-FL	47.85														47.85
5-AL	459.13	78.66	78.07				134.61	34.94							785.40
6-TN	1029.54					419.17		146.02							1594.72
7-IN	2357.89														2357.89
8-MI	338.57				14.48										353.05
9-WI	638.12														638.12
10-IL	2425.16														2425.16
11-AR	72.97														72.97
12-MO	1039.15														1039.15
13-IA	5943.71							502.64	292.84		115.77	19.52			6874.48
14-MN	1539.68														1539.68
15-ND	14.06														14.06
16-NE	2280.07														2280.07
17-KS	409.81														409.81
18-OK	124.20											248.83			373.04
19-TX	352.56											133.12			485.68
20-CO	150.68														150.68
21-MT	116.73									79.48					196.21
22-UT	18.49									10.19			9.99		38.67
23-AZ	78.42														78.42
24-CA	85.26													5.32	90.58
25-OR	75.62									11.61					87.23
26-LA	43.79						11.58								55.37
27-MD	112.96			24.38											137.34
28-NY	102.41														102.41
TOTAL	21958.26	78.66	99.46	258.22	14.48	419.17	146.19	683.60	292.84	101.29	115.77	401.47	9.99	5.32	24584.72

TABLE XLVII

OPTIMAL MEAT SHIPMENT PATTERNS FOR REQUIRED PRODUCTION AND CONSUMPTION AND VARIABLE SLAUGHTER IN ALL REGIONS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT OPEN

Region	Intraregional Shipments	Exporting Regions										Total Pork Demands
		6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	18-OK	
	(mil. lbs., carcass)											
1-PA	143.85		406.36		171.25							721.46
2-NC	841.98											841.98
3-GA	477.93	148.83										626.76
4-FL	29.72						659.79					689.50
5-AL	487.82	66.94			51.86							606.63
6-TN	774.74											774.74
7-IN	1058.17											1058.17
8-MI	219.29						140.75	243.87				603.90
9-WI	310.08											310.08
10-IL	737.47											737.47
11-AR	45.32					13.34	101.20					159.86
12-MO	372.47											372.47
13-IA	222.34											222.34
14-MN	311.21											311.21
15-ND	8.73							41.50				50.23
16-NE	173.27											173.27
17-KS	181.24											181.24
18-OK	212.11											212.11
19-TX	301.67						658.02				19.58	979.27
20-CO	93.59								93.63			187.22
21-MT	121.87							22.47				144.34
22-UT	24.02								115.38			139.40
23-AZ	48.71								121.16	73.30		248.17
24-CA	56.26						413.76		907.76			1377.78
25-OR	54.18							337.28				391.46
26-LA	34.39					259.62						294.02
27-MD	85.31				479.83							565.13
28-NY	63.61			86.27	65.90		2074.01					2289.78
TOTAL	7491.35	215.77	406.36	86.27	768.84	272.97	4047.52	645.11	1242.92	73.30	19.58	15270.00

TABLE XLVIII

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR REQUIRED PRODUCTION AND CONSUMPTION AND VARIABLE SLAUGHTER IN ALL REGIONS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT CLOSED

		Exporting Regions														
Region	Intraregional Shipments	3-GA	4-FL	7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
							(mil. lbs., live)									
1-PA	232.07															232.07
2-NC	1100.36		65.76	233.84												1399.96
3-GA	769.47															769.47
4-FL	47.85															47.85
5-AL	459.13	78.66	33.42				134.61	79.58								785.40
6-TN	1029.54					419.17		146.02								1594.73
7-IN	2357.89															2357.89
8-MI	338.57				14.48											353.05
9-WI	638.12															638.12
10-IL	2425.16															2425.16
11-AR	72.97															72.97
12-MO	1039.15															1039.15
13-IA	5943.71							457.62	292.84		115.77	272.34				7082.28
14-MN	1539.68															1539.68
15-ND	14.06															14.06
16-NE	2280.07															2280.07
17-KS	409.81															409.81
18-OK	120.43															120.43
19-TX	352.56											129.47	3.65			485.68
20-CO	150.68															150.68
21-MT	116.73									79.48						196.21
22-UT	18.49									10.19				10.00		38.68
23-AZ	78.42															78.42
24-CA	85.26														5.32	90.58
25-OR	75.62									11.61						87.23
26-LA	43.79						11.58									55.37
27-MD	112.96			24.38												137.34
28-NY	102.41															102.41
TOTAL	21954.96	78.66	99.18	258.22	14.48	419.17	146.19	683.22	292.84	101.28	115.77	401.81	3.65	10.00	5.32	24584.75

TABLE XLIX

OPTIMAL MEAT SHIPMENT PATTERNS FOR REQUIRED PRODUCTION AND CONSUMPTION AND VARIABLE SLAUGHTER IN ALL REGIONS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT CLOSED

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	Total Pork Demands
	(mil. lbs., carcass)										
1-PA	144.14		410.28		131.56						685.98
2-NC	869.54										869.54
3-GA	477.93	169.94									647.87
4-FL	29.72						683.43				713.15
5-AL	487.82	20.94			118.03						626.79
6-TN	799.63										799.63
7-IN	1054.25										1054.25
8-MI	219.29			87.87			42.67	251.90			601.73
9-WI	308.48										308.48
10-IL	733.88										733.88
11-AR	45.32					5.21	114.43				164.96
12-MO	370.55										370.55
13-IA	220.95										220.95
14-MN	309.11										309.11
15-ND	8.73							41.29			50.02
16-NE	172.29										172.29
17-KS	180.37										180.37
18-OK	74.80						69.87			74.18	218.85
19-TX	301.67						710.86				1012.53
20-CO	93.59								90.76		184.35
21-MT	121.87							20.51			142.38
22-UT	24.02								113.58		137.60
23-AZ	48.71								196.76		245.47
24-CA	56.26						464.36		842.80		1363.42
25-OR	54.18							333.51			387.69
26-LA	34.39					269.67					304.06
27-MD	85.31				499.38						584.69
28-NY	63.61				23.47		2092.35				2179.43
TOTAL	7390.41	190.88	410.28	87.87	772.44	274.88	4177.97	647.21	1243.90	74.18	15270.02

TABLE L

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER AND 1979 SPATIAL EQUILIBRIUM DEMANDS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT OPEN

Region	Intraregional Shipments	Exporting Regions											Total Live Hog Demands
		7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	20-CO	23-AZ	
	(mil. lbs., live)												
1-PA	241.47												241.47
2-NC	1111.36	244.23											1355.59
3-GA	769.47												769.47
4-FL	47.85												47.85
5-AL	463.72				136.78	184.90							785.40
6-TN	866.23			446.85		281.64							1594.72
7-IN	2357.79												2357.79
8-MI	348.79	15.04	20.81										384.64
9-WI	638.12												638.12
10-IL	2425.16												2425.16
11-AR	72.97												72.97
12-MO	1039.15												1039.15
13-IA	6123.21					231.97	310.73		139.21	39.53			6844.65
14-MN	1539.68												1539.68
15-ND	14.06												14.06
16-NE	2280.07												2280.07
17-KS	409.81												409.81
18-OK	125.45									247.59			373.04
19-TX	363.21									122.47			485.68
20-CO	150.68												150.68
21-MT	116.73							79.48					196.21
22-UT	18.49							8.63			11.55		38.67
23-AZ	78.42												78.42
24-CA	85.26											5.32	90.58
25-OR	75.62												75.62
26-LA	43.79				11.58								55.37
27-MD	112.96	24.38											137.34
28-NY	102.41												102.41
TOTAL	22021.93	283.65	20.81	446.85	148.36	698.51	310.73	88.11	139.21	409.59	11.55	5.32	24584.62

TABLE LI

OPTIMAL MEAT SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER AND 1979 SPATIAL EQUILIBRIUM DEMANDS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT OPEN

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	18-OK	Total Pork Demands
						(mil. lbs., carcass)						
1-PA	149.98		406.36		165.13							721.47
2-NC	841.98											841.98
3-GA	477.93	148.83										626.76
4-FL	29.72						659.79					689.51
5-AL	487.82	66.94			51.86							606.62
6-TN	774.74											774.74
7-IN	1058.17											1058.17
8-MI	238.91						128.34	236.65				603.90
9-WI	310.08											310.08
10-IL	737.47											737.47
11-AR	45.32					13.34	101.20					159.86
12-MO	372.47											372.47
13-IA	222.34											222.34
14-MN	311.21											311.21
15-ND	8.73							41.50				50.23
16-NE	173.27											173.27
17-KS	181.24											181.24
18-OK	212.12											212.12
19-TX	301.67						658.02				19.58	979.27
20-CO	93.59								93.63			187.22
21-MT	121.87							22.47				144.34
22-UT	24.02								115.38			139.40
23-AZ	48.71								126.16	73.30		248.17
24-CA	56.26						413.76		907.76			1377.78
25-OR	46.97							344.49				391.46
26-LA	34.39					259.62						294.01
27-MD	85.31				479.83							565.14
28-NY	63.61			86.27	72.03		2067.88					2289.79
TOTAL	7509.90	215.77	406.36	86.27	768.85	272.96	4028.99	645.11	1242.93	73.30	19.58	15270.02

TABLE LII

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER AND 1979 SPATIAL EQUILIBRIUM DEMANDS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT CLOSED

Region	Intraregional Shipments	Exporting Regions 7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
							(mil. lbs., live)							
1-PA	241.47													241.47
2-NC	1111.36	244.23												1355.59
3-GA	769.47													769.47
4-FL	47.85													47.85
5-AL	463.72				136.78	184.90								785.40
6-TN	866.06			446.85		281.81								1594.72
7-IN	2357.89													2357.89
8-MI	348.79	15.04	20.81											384.64
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21					231.80	310.73		139.21	292.30				7097.25
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.07													2280.07
17-KS	409.81													409.81
18-OK	120.43													120.43
19-TX	363.21									117.62	4.85			485.68
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.49							8.63				11.55		38.67
23-AZ	78.42													78.42
24-CA	85.26												5.32	90.58
25-OR	75.62													75.62
26-LA	43.79				11.58									55.37
27-MD	112.96	24.38												137.34
28-NY	102.41													102.41
TOTAL	22016.84	283.65	20.81	446.85	148.36	698.51	310.73	88.11	139.21	409.92	4.85	11.55	5.32	24584.71

TABLE LIII

OPTIMAL MEAT SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER AND 1979 SPATIAL EQUILIBRIUM DEMANDS, WILSON FOODS CORPORATION'S OKLAHOMA CITY PLANT CLOSED

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	Total Pork Demands
	(mil. lbs., carcass)										
1-PA	149.98		406.36		165.12						721.46
2-NC	841.98										841.98
3-GA	477.93	148.83									626.76
4-FL	29.72						659.78				689.50
5-AL	487.82	66.94			51.86						606.62
6-TN	774.74										774.74
7-IN	1058.17										1058.17
8-MI	238.91						128.34	236.65			603.90
9-WI	310.08										310.08
10-IL	737.47										737.47
11-AR	45.32					13.34	101.20				159.86
12-MO	372.47										372.47
13-IA	222.34										222.34
14-MN	311.21										311.21
15-ND	8.73							41.50			50.23
16-NE	173.27										173.27
17-KS	181.24										181.24
18-OK	74.80						64.01			73.30	212.11
19-TX	301.67						677.61				979.28
20-CO	93.59								93.63		187.22
21-MT	121.87							22.47			144.34
22-UT	24.02								115.38		139.40
23-AZ	48.71								199.46		248.17
24-CA	56.26						487.06		834.46		1377.78
25-OR	46.97							344.49			391.46
26-LA	34.39					259.62					294.01
27-MD	85.31				479.83						565.14
28-NY	63.61			86.27	72.03		2067.88				2289.79
TOTAL	7372.58	215.77	406.36	86.27	768.84	272.96	4185.88	645.11	1242.93	73.30	15270.00

TABLE LIV

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER WITH NEW PACKER IN OMAHA, NEBRASKA

Region	Intraregional Shipments	Exporting Regions 7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
							(mil. lbs., live)							
1-PA	241.47													241.47
2-NC	1111.36	244.23												1355.59
3-GA	769.47													769.47
4-FL	47.85													47.85
5-AL	463.72				136.78	184.90								785.40
6-TN	813.42			446.85		334.46								1594.72
7-IN	2357.89													2357.89
8-MI	348.79	15.04	20.81											384.64
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21					178.87	310.73			4.44				6617.25
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.07													2280.07
17-KS	409.81													409.81
18-OK	120.43													120.43
19-TX	363.21									117.62	4.85			485.68
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.49							8.63				11.55		38.67
23-AZ	78.42													78.42
24-CA	85.26												5.32	90.58
25-OR	75.62													75.62
26-LA	43.79				11.58									53.37
27-MD	112.96	24.38												137.34
28-NY	102.41													102.41
29-OM									190.89	289.11				480.00
TOTAL	21964.17	283.64	20.81	446.85	148.36	698.23	310.73	88.12	190.89	411.17	4.85	11.55	5.32	24584.00

TABLE LV

OPTIMAL MEAT SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER WITH NEW PACKER IN OMAHA, NEBRASKA

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	29-OM	Total Pork Demands
	(mil. lbs., carcass)											
1-PA	149.98		406.36		165.13							721.47
2-NC	841.98											841.98
3-GA	477.93	148.83										626.76
4-FL	29.72						659.79					689.51
5-AL	487.82	66.94			51.86							606.62
6-TN	774.74											774.74
7-IN	1058.17											1058.17
8-MI	238.91			86.27			42.08	236.65				603.91
9-WI	310.08											310.08
10-IL	737.47											737.47
11-AR	45.32					13.34	101.20					159.86
12-MO	372.47											372.47
13-IA	222.34											222.34
14-MN	311.21											311.21
15-ND	8.73							41.50				50.23
16-NE	173.27											173.27
17-KS	181.24											181.24
18-OK	74.80						64.01			73.30		212.11
19-TX	301.67						677.61					979.28
20-CO	93.59										93.63	187.22
21-MT	121.87							22.47				144.34
22-UT	24.02								115.38			139.40
23-AZ	48.71								168.22		31.24	248.17
24-CA	56.26						188.92		959.32		173.27	1377.77
25-OR	46.97							344.49				391.46
26-LA	34.39					259.62						294.01
27-MD	85.31				479.83							565.14
28-NY	63.61				72.03		2154.15					2289.79
TOTAL	7372.58	215.77	406.36	86.27	768.85	272.96	3887.76	645.11	1242.92	73.30	298.14	15270.02

TABLE LVI

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER WITH NEW PACKER IN KIRKSVILLE, MISSOURI

Region	Intraregional Shipments	Exporting Regions 7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
							(mil. lbs., live)							
1-PA	236.73													236.73
2-NC	1111.36	244.23												1355.59
3-GA	769.47													769.47
4-FL	47.85													47.85
5-AL	463.72				136.78					184.90				785.40
6-TN	872.21	15.01		446.85		260.65								1594.72
7-IN	2357.89													2357.89
8-MI	348.79		20.81											369.60
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21						310.73		139.21	69.20				6642.34
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.07													2280.07
17-KS	409.81													409.81
18-OK	120.43													120.43
19-TX	363.21									117.62	4.85			485.68
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.49							3.30				11.55	5.33	38.67
23-AZ	78.42													78.42
24-CA	85.26													85.26
25-OR	75.62													75.62
26-LA	43.79				11.58									55.37
27-MD	112.96	24.38												137.34
28-NY	102.41													102.41
29-KV						443.66				36.34				480.00
TOTAL	22018.23	283.62	20.81	446.85	148.36	704.31	310.73	81.79	139.21	408.06	4.85	11.55	5.33	24584.70

TABLE LVII

OPTIMAL MEAT SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER WITH NEW PACKER IN KIRKSVILLE, MISSOURI

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	29-KV	Total Pork Demands
	(mil. lbs., carcass)											
1-PA	147.04		406.36		168.07							721.47
2-NC	841.98											841.98
3-GA	477.93	148.83										626.76
4-FL	29.72						361.65				298.14	689.51
5-AL	487.82	66.94			51.86							606.62
6-TN	774.74											774.74
7-IN	1058.17											1058.17
8-MI	229.57			86.27			51.42	236.65				603.91
9-WI	310.08											310.08
10-IL	737.47											737.47
11-AR	45.32					13.34	101.20					159.86
12-MO	372.47											372.47
13-IA	222.34											222.34
14-MN	311.21											311.21
15-ND	8.73							41.50				50.23
16-NE	173.27											173.27
17-KS	181.24											181.24
18-OK	74.80						64.01			73.30		212.11
19-TX	301.67						677.61					979.78
20-CO	93.59								93.63			187.22
21-MT	121.87							22.47				144.34
22-UT	24.02								115.38			139.40
23-AZ	48.71								199.46			248.17
24-CA	52.96						490.36		834.46			1377.78
25-OR	46.97							344.49				391.46
26-LA	34.39					259.62						294.01
27-MD	85.31				479.83							565.14
28-NY	63.61				69.08		2157.09					2289.78
TOTAL	7357.00	215.77	406.36	86.27	768.84	272.96	3903.34	645.11	1242.93	73.30	298.14	15270.02

TABLE LVIII

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER WITH NEW PACKER IN ALBERT LEA, MINNESOTA

Region	Intraregional Shipments	Exporting Regions 7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
							(mil. lbs., live)							
1-PA	241.47													241.47
2-NC	1111.36	244.23												1355.29
3-GA	769.46													769.46
4-FL	47.85													47.85
5-AL	463.72				136.78					184.90				785.40
6-TN	870.39	15.01		11.49		697.82								1594.71
7-IN	2357.89													2357.89
8-MI	348.79													348.79
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21						290.52		139.21	105.48				6658.42
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.07													2280.07
17-KS	409.81													409.81
18-OK	120.43													120.43
19-TX	363.21									117.62	4.85			485.98
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.49							3.30				11.53	5.33	38.65
23-AZ	78.42													78.42
24-CA	85.26													85.26
25-OR	75.62													75.62
26-LA	43.79				11.58									55.37
27-MD	112.96	24.38												137.34
28-NY	102.41													102.41
29-AM			20.96	438.89			20.15							480.00
TOTAL	22021.16	283.62	20.96	450.38	148.36	697.82	310.67	82.78	139.21	408.00	4.85	11.53	5.33	24584.67

TABLE LIX

OPTIMAL MEAT SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER WITH NEW PACKER IN ALBERT LEA, MINNESOTA

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	29-AM	Total Pork Demands
	(mil. lbs., carcass)											
1-PA	149.98		406.36		165.13							721.47
2-NC	841.98											841.98
3-GA	477.93	148.83										626.76
4-FL	29.72						659.79					689.51
5-AL	487.82	66.94			51.86							606.62
6-TN	774.74											774.74
7-IN	1058.17											1058.17
8-MI	225.98							236.65			141.27	603.90
9-WI	310.08											310.08
10-IL	737.47											737.47
11-AR	45.32					13.34	101.20					159.86
12-MO	372.47											372.47
13-IA	222.34											222.34
14-MN	311.21											311.21
15-ND	8.73							41.50				50.23
16-NE	173.27											173.27
17-KS	181.24											181.24
18-OK	74.80						64.01			73.30		212.11
19-TX	301.67						677.61					979.28
20-CO	93.59								93.63			187.22
21-MT	121.87							22.47				144.34
22-UT	21.97								117.43			139.40
23-AZ	48.71								199.46			248.17
24-CA	52.96						492.42		832.40			1377.78
25-OR	46.97							344.49				391.46
26-LA	34.39					259.62						294.01
27-MD	85.31				479.83							565.14
28-NY	63.61			86.27	72.03		1911.02				156.87	2289.80
TOTAL	7354.30	215.77	406.36	86.27	768.85	272.96	3906.05	645.11	1242.92	73.30	298.14	15270.03

TABLE LX

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER WITH NEW PACKER IN DAVENPORT, IOWA

Region	Intraregional Shipments	Exporting Regions											Total Live Hog Demands
		7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	
							(mil. lbs., live)							
1-PA	241.47													241.47
2-NC	1111.36	244.23												1355.59
3-GA	769.47													769.47
4-FL	47.85													47.85
5-AL	463.72				136.78					184.90				785.40
6-TN	870.39	15.01		11.49		697.82								1594.71
7-IN	2357.89													2357.89
8-MI	348.79													348.79
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21						290.52		139.21	105.48				6658.42
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.07													2280.07
17-KS	409.81													409.81
18-OK	120.43													120.43
19-TX	363.21									117.62	4.85			485.68
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.86							3.30				11.55	5.33	39.04
23-AZ	78.42													78.42
24-CA	85.26													85.26
25-OR	75.62				11.58									75.62
26-LA	43.79				11.58									55.37
27-MD	112.96	24.38												137.34
28-NY	102.41													102.41
29-DV			20.96	438.88			20.16							480.00
TOTAL	22021.54	283.62	20.96	450.37	148.36	697.82	310.68	82.78	139.21	408.00	4.85	11.55	5.33	24584.68

TABLE LXI

OPTIMAL MEAT SHIPMENT PATTERNS FOR VARIABLE PRODUCTION AND SLAUGHTER WITH NEW PACKER IN DAVENPORT, IOWA

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	29-DV	Total Pork Demands
	(mil. lbs., carcass)											
1-PA	149.98		406.36		165.13							721.47
2-NC	841.98											841.98
3-GA	477.93	148.83										626.76
4-FL	29.72						659.79					689.51
5-AL	487.82	66.94			51.86							606.62
6-TN	774.74											774.74
7-IN	1058.17											1058.17
8-MI	216.64							236.65			150.61	603.90
9-WI	310.08											310.08
10-IL	737.47											737.47
11-AR	45.32					13.34	101.20					159.86
12-MO	372.47											372.47
13-IA	222.34											222.34
14-MN	311.21											311.21
15-ND	8.73							41.50				50.23
16-NE	173.27											172.27
17-KS	181.24											181.24
18-OK	74.80						64.01			73.30		242.11
19-TX	301.67						677.61					977.28
20-CO	93.59								93.63			187.22
21-MT	121.87							22.47				144.34
22-UT	24.02								115.38			139.40
23-AZ	48.71								199.46			248.17
24-CA	52.96						490.36		834.46			1377.78
25-OR	46.97							344.49				391.46
26-LA	34.39					259.62						294.01
27-MD	85.31				479.83							565.14
28-MD	63.61			86.27	72.03		1920.36				147.53	2289.80
TOTAL	7347.01	215.77	406.36	86.27	768.85	270.96	3913.33	645.11	1242.93	73.30	298.14	15270.03

TABLE LXII

OPTIMAL LIVE HOG SHIPMENT PATTERNS WITH UNIONIZED WAGE RATES IN THE SLAUGHTER SECTOR

Region	Intraregional Shipments	Exporting Regions 7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
							(mil. lbs., live)							
1-PA	241.47													241.47
2-NC	1111.36	259.13												1370.49
3-GA	769.47													769.47
4-FL	47.85													47.85
5-AL	463.72				136.78	184.90								785.40
6-TN	866.19			446.85		281.68								1594.72
7-IN	2357.89													2357.89
8-MI	348.79		20.81											369.60
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21					231.94	310.73		139.21	292.30				7097.39
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.07													2280.07
17-KS	409.81													409.81
18-OK	120.43													120.43
19-TX	363.21									117.62	4.85			485.68
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.49							8.63				11.55		38.67
23-AZ	78.42													78.42
24-CA	85.26												5.32	90.58
25-OR	75.62													75.62
26-LA	43.79				11.58									55.37
27-MD	112.96	24.38												137.34
28-NY	102.41													102.41
TOTAL	22016.97	283.51	20.81	446.85	148.36	698.52	310.73	88.11	139.21	409.92	4.85	11.55	5.32	24584.71

TABLE LXIII

OPTIMAL MEAT SHIPMENT PATTERNS WITH UNIONIZED WAGE RATES IN THE SLAUGHTER SECTOR

Region	Intraregional Shipments	Exporting Regions 2-NC	6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	Total Pork Demands
						(mil. lbs., carcass)						
1-PA	149.98			406.36		165.13						721.47
2-NC	841.98											841.98
3-GA	477.93		148.83									626.76
4-FL	29.72							659.79				689.51
5-AL	487.82		66.94			51.86						606.62
6-TN	774.74											774.74
7-IN	1058.17											1058.17
8-MI	229.57				86.27			51.42	236.65			603.91
9-WI	310.08											310.08
10-IL	737.47											737.47
11-AR	45.32						13.34	101.20				159.86
12-MO	372.47											372.47
13-IA	222.34											222.34
14-MN	311.21											311.21
15-ND	8.73								41.50			50.23
26-NE	173.27											173.27
17-KS	181.24											181.24
18-OK	74.80							64.01			73.30	212.11
19-TX	301.67							677.61				979.28
20-CO	93.59									93.63		187.22
21-MT	121.87								22.47			144.34
22-UT	24.02									115.38		139.40
23-AZ	48.71									199.46		248.17
24-CA	56.26							487.06		834.46		1377.78
25-OR	46.97								344.49			391.46
26-LA	34.39						259.62					294.01
27-MD	85.31	9.26				470.57						565.14
28-NY	63.61					81.28		2144.90				2289.79
TOTAL	7363.24	9.26	215.77	406.36	86.27	768.84	272.96	4185.99	645.11	1242.93	73.30	15270.03

TABLE LXIV

OPTIMAL LIVE HOG SHIPMENT PATTERNS WITH NON-UNIONIZED
WAGE RATES IN THE SLAUGHTER SECTOR

Region	Intraregional Shipments	Exporting Regions 7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
							(mil. lbs., live)							
1-PA	241.47													241.47
2-NC	1111.36													1111.36
3-GA	769.47													769.47
4-FL	47.85													47.85
5-AL	463.72				136.78	184.90								785.40
6-TN	865.08			217.29		512.35								1594.72
7-IN	2357.89													2357.89
8-MI	348.79	286.04	20.81	229.41										885.05
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21						310.73		139.21	292.30				6865.45
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.07													2280.07
17-KS	409.81													409.81
18-OK	120.42													120.42
19-TX	363.21									117.62	4.85			485.68
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.49							8.63				11.55		38.67
23-AZ	78.42													78.42
24-CA	85.26												5.32	90.58
25-OR	75.62													75.62
26-LA	43.79				11.58									55.37
27-MD	112.96													112.96
28-NY	102.41													102.41
TOTAL	22015.85	286.04	20.81	446.70	148.36	697.25	310.73	88.11	139.21	409.92	4.85	11.55	5.32	24584.70

TABLE LXV

OPTIMAL MEAT SHIPMENT PATTERNS WITH NON-UNIONIZED WAGE RATES IN THE SLAUGHTER SECTOR

Region	Intraregional Shipments	Exporting Regions									Total Pork Demands
		6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	
	(mil. lbs., carcass)										
1-PA	149.98		406.36		165.13						721.47
2-NC	690.29				151.70						841.99
3-GA	477.93	148.83									626.76
4-FL	29.72						659.79				689.51
5-AL	487.82	66.94			38.52	13.34					606.62
6-TN	774.74										774.74
7-IN	1058.17										1058.17
8-MI	549.72							54.18			603.90
9-WI	310.08										310.08
10-IL	737.47										737.47
11-AR	45.32						114.54				159.86
12-MO	372.47										372.47
13-IA	222.34										222.34
14-MN	311.21										311.21
15-ND	8.73							41.50			50.23
16-NE	173.27										173.27
17-	181.24										181.24
18-OK	74.80						64.01			73.30	212.11
19-TX	301.67						677.61				979.28
20-CO	93.59								93.63		187.22
21-MT	121.87							22.47			144.34
22-UT	24.02								115.38		139.40
23-AZ	48.71								199.46		248.17
24-CA	56.26						487.06		834.46		1377.78
25-OR	46.97							344.49			391.46
26-LA	34.39					259.62					294.01
27-MD	70.16				413.50		81.47				565.13
28-NY	63.61			86.27			1957.44	182.47			2289.79
TOTAL	7516.55	215.77	406.36	86.27	768.85	272.96	4041.92	645.11	1242.43	73.30	15270.02

TABLE LXVI

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR FUEL PRICE INCREASES OF 10, 20, 30, AND 40 PERCENT

Region	Intraregional Shipments	Exporting Regions 7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
							(mil. lbs., live)							
1-PA	241.47													241.47
2-NC	1111.36	244.23												1355.59
3-GA	769.47													769.47
4-FL	47.85													47.85
5-AL	463.72				136.78	184.90								785.40
6-TN	866.06			446.85		281.81								1594.72
7-IN	2357.89													2357.89
8-MI	348.79	15.04	20.81											384.64
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21					231.80	310.73		139.21	292.30				7097.25
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.07													2280.07
17-KS	409.81													409.81
18-OK	120.43													120.43
19-TX	363.21									117.62	4.85			485.68
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.49							8.63				11.55		38.67
23-AZ	78.42													78.42
24-CA	85.26												5.32	90.58
25-OR	75.62													75.62
26-LA	43.79				11.58									55.37
27-MD	112.96	24.38												137.34
28-NY	102.41													102.41
TOTAL	22016.84	283.65	20.81	446.85	148.36	698.51	310.73	88.11	139.21	409.92	4.85	11.55	5.32	24584.71

TABLE LXVII

OPTIMAL LIVE HOG SHIPMENT PATTERNS FOR A FUEL PRICE INCREASE OF 50 PERCENT

Region	Intraregional Shipments	Exporting Regions 7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
	(mil. lbs., carcass)													
1-PA	241.47													241.47
2-NC	1111.36	244.23												1355.59
3-GA	769.47													769.47
4-FL	47.85													47.85
5-AL	463.72				136.78	184.90								785.40
6-TN	871.35			446.85		276.52								1594.72
7-IN	2357.89													2357.89
8-MI	348.79	15.04	20.81											384.64
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21					237.13	310.73		139.21	292.30				7102.58
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.06													2280.06
17-KS	409.81													409.81
18-OK	120.43													120.43
19-TX	363.21									117.62	4.85			485.68
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.49							3.30				11.55	5.33	38.67
23-AZ	78.42													78.42
24-CA	85.26													85.26
25-OR	75.62													75.62
26-LA	43.79				11.58									55.37
27-MD	112.96	24.38												137.34
28-NY	102.41													102.41
TOTAL	22022.12	283.65	20.81	446.85	148.36	698.55	310.73	82.78	139.21	409.92	4.85	11.55	5.33	24584.71

TABLE LXVIII

OPTIMAL MEAT SHIPMENT PATTERNS FOR A FUEL PRICE INCREASE OF 10 PERCENT

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	Total Pork Demands
	(mil. lbs., live)										
1-PA	149.98		406.36		165.12						721.46
2-NC	841.98										841.98
3-GA	477.93	148.83									626.76
4-FL	29.72						659.78				689.50
5-AL	487.82	66.94			51.86						606.62
6-TN	774.74										774.74
7-IN	1058.17										1058.17
8-MI	238.91						128.34	236.65			603.90
9-WI	310.08										310.08
10-IL	737.47										737.47
11-AR	45.32					13.34	101.20				159.86
12-MO	372.47										372.47
13-IA	222.34										222.34
14-MN	311.21										311.21
15-ND	8.73							41.50			50.23
16-NE	173.27										173.27
17-KS	181.24										181.24
18-OK	74.80						64.01			73.30	212.11
19-TX	301.67						677.61				979.28
20-CO	93.59								93.63		187.22
21-MT	121.87							22.47			144.34
22-UT	24.02								115.38		139.40
23-AZ	48.71								199.46		248.17
24-CA	56.26						487.06		834.46		1377.78
25-OR	46.97							344.49			391.46
26-LA	34.39					259.62					294.01
27-MD	85.31				479.83						565.14
28-NY	63.61			86.27	72.03		2067.88				2289.79
TOTAL	7372.58	215.77	406.36	86.27	768.84	272.96	4185.88	645.11	1242.93	73.30	15270.00

TABLE LXIX

OPTIMAL MEAT SHIPMENT PATTERNS FOR A FUEL PRICE INCREASE OF 20 PERCENT

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	Total Pork Demands
	(mil. lbs., carcass)										
1-PA	149.98		571.48								721.46
2-NC	841.98										841.98
3-GA	477.93	148.83									626.76
4-FL	29.72						659.79				689.51
5-AL	487.82	66.94			51.86						606.62
6-TN	774.74										774.74
7-IN	893.05				165.13						1058.18
8-MI	238.91			86.27			42.08	236.65			603.91
9-WI	310.08										310.08
10-IL	737.47										737.47
11-AR	45.32					13.34	101.20				159.86
12-MO	372.47										372.47
13-IA	222.34										222.34
14-MN	311.21										311.21
15-ND	8.73							41.50			50.23
16-NE	173.27										173.27
17-KS	181.24										181.24
18-OK	74.80						64.01			73.30	212.11
19-TX	301.67						677.61				979.28
20-CO	93.59								93.63		187.22
21-MT	121.87							22.47			144.34
22-UT	24.02								115.38		139.40
23-AZ	48.71								199.46		248.17
24-CA	56.26						487.06		834.46		1377.78
25-OR	46.97							344.46			391.46
26-LA	34.39					259.62					294.01
27-MD	85.31				479.83						565.14
28-NY	63.61				72.03		2154.15				2289.79
TOTAL	7207.46	215.77	571.48	86.27	768.85	272.96	4185.90	645.11	1242.93	73.30	15270.03

TABLE LXX

OPTIMAL MEAT SHIPMENT PATTERNS FOR A FUEL PRICE INCREASE OF 30 PERCENT

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	Total Pork Demands
						(mil. lbs., live)					
1-PA	149.98		571.48								721.46
2-NC	841.98										841.98
3-GA	477.93	148.83									626.76
4-FL	29.72						659.79				689.51
5-AL	487.82	66.94			51.86						606.62
6-TN	774.74										774.74
7-IN	893.05				165.13						1058.18
8-MI	238.91			86.27			278.73				603.91
9-WI	310.08										310.08
10-IL	737.47										737.47
11-AR	45.32					13.34	101.20				159.86
12-MO	372.47										372.47
13-IA	222.34										222.34
14-MN	311.21										311.21
15-ND	8.73							41.50			50.23
16-NE	173.27										173.27
17-KS	181.24										181.24
18-OK	74.80						64.01			73.30	212.11
19-TX	301.67						677.61				979.28
20-CO	93.59								93.63		187.22
21-MT	121.87							22.47			144.34
22-UT	24.02								115.38		139.40
23-AZ	48.71								199.46		248.17
24-CA	56.26						487.06		834.46		1377.78
25-OR	46.97							344.49			391.46
26-LA	34.39					259.62					294.01
27-MD	85.31				479.83						565.14
28-NY	63.61				72.03		1917.50	236.65			2289.79
TOTAL	7207.46	215.77	571.48	86.27	768.85	272.96	4185.90	645.11	1242.93	73.30	15270.03

TABLE LXXI

OPTIMAL MEAT SHIPMENT PATTERNS FOR A FUEL PRICE INCREASE OF 40 PERCENT

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	Total Pork Demands
		(mil. lbs., carcass)									
1-PA	149.98		571.48								721.46
2-NC	841.98										841.98
3-GA	477.93	148.83									626.76
4-FL	29.72						659.79				689.51
5-AL	487.82	66.94			51.86						606.62
6-TN	774.74										774.74
7-IN	893.06				165.13						1058.19
8-MI	238.91			86.27			278.73				603.91
9-WI	310.08										310.08
10-IL	737.47										737.47
11-AR	45.32					13.34	101.20				159.86
12-MO	372.47										372.47
13-IA	222.34										222.34
14-MN	311.21										311.21
15-ND	8.73							41.50			50.23
16-NE	173.27										173.27
17-KS	181.24										181.24
18-OK	74.80						64.01			73.30	212.11
19-TX	301.67						677.61				979.28
20-CO	93.59								93.63		187.22
21-MT	121.87							22.47			144.34
22-UT	24.02								115.38		139.40
23-AZ	48.71								199.46		248.17
24-CA	56.26						487.05		834.46		1377.77
25-OR	46.97							344.49			391.46
26-LA	34.39					259.62					294.01
27-MD	85.31				479.83						565.14
28-NY	63.61				72.03		1917.50	236.65			2289.79
TOTAL	7207.47	215.77	571.48	86.27	768.85	272.96	4185.89	645.11	1242.93	73.30	15270.03

TABLE LXXII

OPTIMAL MEAT SHIPMENT PATTERNS FOR A FUEL PRICE INCREASE OF 50 PERCENT

Region	Intraregional Shipments	Exporting Regions									Total Pork Demands
		6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	
	(mil. lbs., live)										
1-PA	149.98				571.48						721.46
2-NC	841.98										841.98
3-GA	477.93	148.83									626.76
4-FL	29.72						659.79				689.51
5-AL	487.82	66.94			51.86						606.62
6-TN	774.74										774.74
7-IN	1058.17										1058.17
8-MI	238.91			86.27			278.73				603.91
9-WI	310.08										310.08
10-IL	737.47										737.47
11-AR	45.32					13.34	101.20				159.86
12-MO	372.47										372.47
13-IA	222.34										222.34
14-MN	311.21										311.21
15-ND	8.73							41.50			50.23
16-NE	173.27										173.27
17-KS	181.24										181.24
18-OK	74.80						64.01			73.30	212.11
19-TX	301.67						677.61				979.28
20-CO	93.59								93.63		187.22
21-MT	121.87							22.47			144.34
22-UT	24.02								115.38		139.40
23-AZ	48.71								199.46		248.17
24-CA	52.96						490.36		834.46		1377.78
25-OR	46.97							344.49			391.46
26-LA	34.39					259.62					294.01
27-MD	85.31		406.36		73.47						565.14
28-NY	63.61				72.03		1917.50	236.65			2289.79
TOTAL	7369.28	215.77	406.36	86.27	768.84	272.96	4189.20	645.11	1242.93	73.30	15270.02

TABLE LXXIII

OPTIMAL LIVE HOG SHIPMENT PATTERNS TO SATISFY DEMANDS FOR PROJECTED 1990 POPULATION DISTRIBUTIONS

Region	Intraregional Shipments	Exporting Regions 7-IN	9-WI	10-IL	11-AR	12-MO	14-MN	15-ND	16-NE	17-KS	18-OK	20-CO	23-AZ	Total Live Hog Demands
	(mil. lbs., carcass)													
1-PA	241.47													241.47
2-NC	1111.36	310.22		60.67										1482.24
3-GA	769.47													769.47
4-FL	47.85													47.85
5-AL	463.72				136.78	184.90								785.40
6-TN	816.21			385.69		392.82								1594.72
7-IN	2357.89													2357.89
8-MI	348.79		20.81											369.60
9-WI	638.12													638.12
10-IL	2425.16													2425.16
11-AR	72.97													72.97
12-MO	1039.15													1039.15
13-IA	6123.21					120.19	310.73		139.21	292.30				6985.63
14-MN	1539.68													1539.68
15-ND	14.06													14.06
16-NE	2280.07													2280.07
17-KS	409.81													409.81
18-OK	120.43													120.43
19-TX	363.21									117.62	4.85			483.68
20-CO	150.68													150.68
21-MT	116.73							79.48						196.21
22-UT	18.49							8.63				11.55		38.67
23-AZ	78.42													78.42
24-CA	85.26												5.32	90.58
25-OR	75.62													75.62
26-LA	43.79				11.58									55.37
27-MD	112.96	24.38												137.34
28-NY	102.41													102.41
TOTAL	21966.97	334.60	20.81	446.35	148.36	697.91	310.73	88.12	139.21	409.92	4.85	11.55	5.32	24584.70

TABLE LXXIV

OPTIMAL MEAT SHIPMENT PATTERNS TO SATISFY DEMANDS FOR PROJECTED 1990 POPULATION DISTRIBUTIONS

Region	Intraregional Shipments	Exporting Regions 6-TN	7-IN	9-WI	10-IL	12-MO	13-IA	14-MN	16-NE	17-KS	Total Pork Demands
	(mil. lbs., live)										
1-PA	149.98		484.07		8.86						642.91
2-NC	920.65										920.65
3-GA	477.93	189.02			32.37						699.32
4-FL	29.72						856.48				886.20
5-AL	487.82				129.11						616.93
6-TN	801.49										801.49
7-IN	980.46										980.46
8-MI	229.57			78.09				272.49			580.15
9-WI	307.75										307.75
10-IL	690.45										690.45
11-AR	45.32					35.63	88.62				169.57
12-MO	353.74										353.74
13-IA	209.28										209.28
14-MN	299.65										299.65
15-ND	8.73							39.36			48.09
16-NE	169.88										169.88
17-KS	168.43										168.43
18-OK	74.80						56.49			86.11	217.40
19-TX	301.67						745.81				1047.48
20-CO	93.59								111.23		204.82
21-MT	121.87							23.82			145.69
22-UT	24.02								118.10		142.12
23-AZ	48.71								222.10		270.81
24-CA	56.26						505.33		794.87		1356.46
25-OR	46.97							321.00			367.97
26-LA	34.39					256.06					290.45
27-MD	85.31				510.06						595.37
28-NY	63.61			10.52	135.46		1876.89				2086.48
TOTAL	7282.05	189.02	484.07	88.61	815.86	291.69	4129.62	656.67	1246.30	86.11	15270.00

VITA

Steven Roger Meyer

Candidate for the Degree of

Master of Science

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